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THE

JOURNAL

OF THE

Franklin Institute,

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DEVOTED TO

Science and the Mechanic Arts.

EDITORS

PROF. HENRY MORTON, PH.D.,

AND

W. H. WAHL, PH. D.

ASSISTED BY THE COMMITTEE ON PUBLICATION.

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

ITEMS AND NOVELTIES.

The Delaware Bridge, between Philadelphia and Camden, N. J.—[Read at the stated meeting of the Franklin Institute, December 21, 1870, by Hector Orr.]—The facts and inferences which I shall offer to the Institute are taken from the highly circumstantial and complete report of the architects of the work, prepared for the information of the Secretary of War, and which has been explicitly commended by the commissioners appointed to examine the same. Each pound of weight and each foot of surface have been carefully ascertained and set forth, leaving nothing farther on the subject to be desired.

From this long array of details we learn that, according to the design, the Bridge will consist of four spans over the water-way, suspended by steel wire cables, and of a raised roadway or approach at each end, at the respective sides of the river. The western ap-

proach begins at the eastern side of Second street, Philadelphia, at an elevation of 36½ feet above low water; ascending by a uniform grade of 5 feet per 100 feet, the roadway attains an elevation of 74·03 feet at the distance of 750 feet east of Second street, at the centre of the first pier. This pier is located immediately east of Delaware avenue. The approach rests partly on embankment with side walls, and partly on arches. Front street, Philadelphia, will be spanned by two arches over the sidewalks, and a central arch over the roadway at an elevation of 20 feet in the centre. At Water street the elevation of the grade admits of an arch over the entire street of 40 feet. Delaware avenue will be spanned by an archway of 50 feet chord.

From the centre of the first *pier* to the centre of the last *tower* the roadway describes an arc of a circle, the versed sine of which is 39 feet; the grades of the respective approaches being tangential to this curve. The Camden approach descends from a distance of 1350 feet, at the rate of 5 feet per hundred feet, terminating 250 feet east of Front street, Camden.

The river Bridge consists of two spans of 762 feet each—two spans of 738 feet each—and one double draw 120 feet in length between centres of piers at low water. The clear elevation above low water of certain points will be,—72 feet at Philadelphia front; 91 feet at centre of first span; 97 feet adjacent to the draw; 111 feet at centre of second span; 110 feet at centre of third span; and 91 feet at centre of fourth span.

The floor of the Bridge and its approaches will be 36 feet in width, divided into a roadway 20 feet in the clear between guards, and 24 feet between curbstones; and two sidewalks, each 6 feet clear of the trusses. Each line of travel is directed by double lines of iron tramways, so arranged as to accommodate vehicles of different gauges. The floor is constructed in such manner as to prevent undue oscillation. The material (except the planking) will be wrought iron. Transverse joists of rolled beams, 8 inches in depth, are placed at intervals of 5 feet, and extend the entire width of the floor. These joists pass between a central rib, composed of two wrought iron beams, respectively 12 inches in depth, forming a compound beam or truss 32 inches in depth, and extending through each of the spans. The floor is farther stiffened by two main wrought iron trusses, 10 feet in height, separating the roadway from the sidewalks, and by handrail trusses of wrought iron 4 feet high, pro-

tecting the sidewalks. Adjacent to the main trusses, and at each side, are built beams of wood 8 × 12, above and below the floor joists, with pieces 8 × 8 packed between the transverse joists. These timbers form continuous ribs, extending throughout the floor, and are not affected by the variations of temperature, and therefore afford an effective medium to resist the horizontal action of the stays. The iron trusses are provided with slip-joints, at intervals of 40 feet, to compensate for variations in length caused by change of temperature. The floor joists will be securely trussed at centre, and fastened by suitable stirrups to the main trusses. The suspenders are attached directly to the floor joists immediately outside of the main trusses. The planking of roadway consists of one course of white pine, 2½ inches thick, laid lengthwise; one similar course laid diagonally; and one upper course of white oak, 2½ inches thick, laid transversely. The sidewalks will have one course of white pine planking and one course of white oak, 2½ inches thick. The lower planking will be bolted to the iron joists, the upper course being secured by wood screws. The lumber will be previously seasoned and treated by an improved preservative process, and be laid with coal tar between each course.

To provide against lateral movement the floor will have a system of effective horizontal bracing. The stays will be attached to the floor at intervals of 15 feet, within the tangent lines of the cables, and will greatly assist in sustaining the floor, reduce oscillation, and partially maintain the equilibrium of adjacent spans when under the effects of unequal loads.

The main cables (two in number) consist each of nineteen strands of steel wire-rope, each 2⅝ inches in diameter, and forming one combined cable, 11⅝ inches in diameter. To these cables are attached the suspenders of iron-wire rope, 1⅝ inches in diameter, at intervals of 5 feet. Near the centre of the spans the suspenders will be of solid round iron bolts, 1¾ inches diameter, to assist in preventing oscillation; and where the suspenders cross the stays they will be combined by wrappings of iron wire.

Saddles, movable on rollers, are provided on the top of each tower, to pass the cables and stays, and allow an equalizing movement between the cables of adjoining spans. When the cables approach the anchorages, they are attached to iron chains, composed of flat links; these will extend down into wells in the solid rock, and will be effectually secured by heavy cast iron anchor plates.

The piers and towers have received the special consideration of the architects and Bridge Company. The *first* pier at Delaware avenue has been designed with particular reference to the accommodation of the Ferry Landing. This pier will consist of masonry founded upon rock bottom. At the level of the avenue an archway 20 feet in width passes through the masonry, east and west. The stone work is carried to the floor level, from which rises the cast iron towers to sustain the cable. The *last* pier will consist of masonry founded on piles driven to the rock, and will terminate with cast iron towers above the roadway. At the draw piers rock is found at the depth of 88 feet below low water.

In place of piers of simple masonry sunk on caissons by the *plenum* process, massive iron cylinders have been designed for the foundation piers and towers. A sufficient number of iron pipes, of adequate section, securely bolted together, on an improved plan suggested by Mr. Speakman, will be driven to, and sunk into, solid rock. The interior will be excavated and filled with concrete. At low water, these cylinders will be capped and firmly braced; the mud will be removed from between and around them, the space enclosed by sheet piling and filled with concrete 10 feet in depth. The exterior, from high water to sufficient depth below low water, will have suitable timber protection to obviate all danger from contact with vessels; and iron ice-breakers of great strength are designed for each pier exposed to the current. At low water the tapering *piers* commence, which consist of iron columns, effectually flanged and bolted together. These are braced in the vertical and horizontal planes by suitable struts and strong wrought iron ties. The *towers* commence at the end of the roadway, and are constructed of tubular columns of cast iron, firmly braced in every direction, and capped by an immense bearing plate, which supports the saddles for the cables.

At centres of the towers the cables are placed 45 feet between centres, and are drawn together near the centres of each span, where they will be 22 feet from centre to centre.

The draw is located at the termination of the first span on the eastern side of the Philadelphia channel. At a distance of 150 feet from the draw piers, the floor lines will diverge, forming two branch bridges, which, with the direct bridge, will be continued to the draw piers. These will be connected with lifting draws, balanced by counter weights, and operated safely and rapidly by the most ap-

proved appliances, so that the draws may be raised or [illegible] half a minute.

GENERAL SUMMARY.

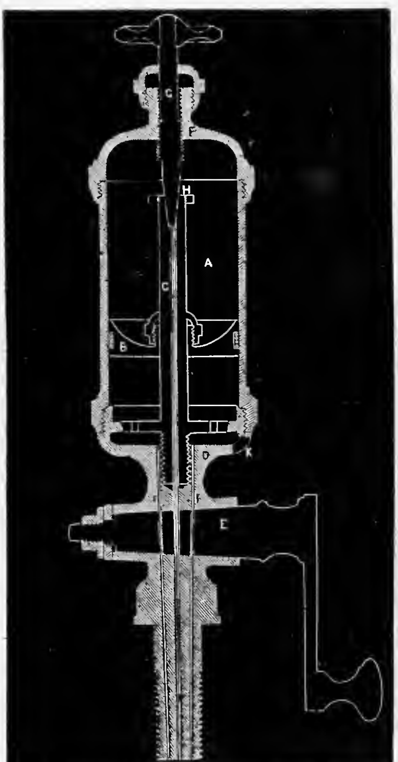
Length of western approach,	750	feet
" of suspended Bridge,	3120	"
" of eastern approach,	1350	"
Total length of Bridge,	[illegible]220	feet
Number of suspended spans,	4	
Length of first span, centre to centre of piers,	762	feet
" of draws, " " "	120	"
" of second span, " " "	758	"
" of third span, " " "	758	"
" of fourth span, " " "	762	"
Height of first pier above low water,	72	"
" of centre of first span above low water,	91	"
" at end next to draw " "	97	"
" of centre of second span " "	111	"
" of " third span " "	110	"
" of " fourth span " "	91	"
" of draw, when raised, " "	171	"
Width of Bridge over all,	36	"
" of roadway clear of guards,	20	"
" of sidewalks in clear,	6	"
Deflection of cables,	75	"
Number of steel cables, main bridge,	2.	
Diameter ditto (19 strands),	$11\frac{7}{8}$	in
" ditto extra cables for draws,	$4\frac{1}{2}$	in.
Total capacity of cables and stays,	11,370	tons.
Ratio of maximum load to ultimate strength, as	1 to 5·2.	
Ultimate strength of anchor chains.	12,000	tons.

We thus have the profile (pictorial and statistical) of a Bridge rather more than a mile in length, intended to connect Pennsylvania with New Jersey, and furnish a means of intercourse for travel and merchandise, independent of all vicissitudes of time and season,—and yet allow the passage up and down the Delaware river of all craft that have hitherto floated upon its waters. At the city of London, England, (whose commerce, certainly, has *some* weight in the social balance,) whenever her great hive swarms out over a few hundred yards of new territory along the Thames river, *a new bridge is built*, without regard to height of masts or rent of wharves and docks, and with no ruin, or even remonstrance, following the act. For her merchants and seamen know, that every mile by which they move their port towards the sea, shortens the voyage and lessens its risk; and if the city will thus insist on crowding

the ships, the "wooden walls" can stand the game quite as long as the brick ones can! In Philadelphia, however, we have a habit of trying to please everybody—and with no better success in general than attended the venerable attempt recorded in our early school books.

Nevertheless, one more attempt in the "conservative" line is here proposed in this Bridge, in which various tastes and interests are consulted; which will spare for the present the *square-rigged* tonnage of even Trenton and Tacony, and yet secure to the city of Philadelphia a proper footing upon her own Delaware.

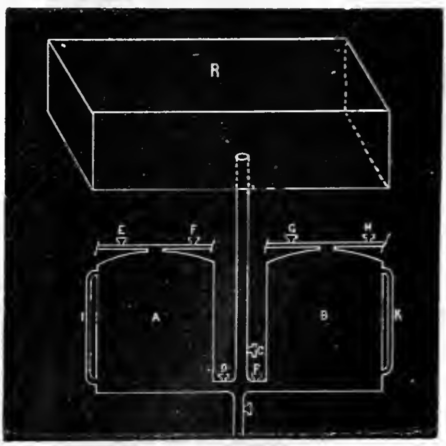
Lubricator.—*David Adamson's Patent, Dec. 7th,* 1869.—This apparatus consists of a piston, B, working in a cylinder, A, and upon an internal tubular rod, C. The cylinder and rod are secured concentrically to the base, D, which latter is connected with the parts to be lubricated by the usual screw joint, and is furnished with a plug, E, and three openings extending through and through, one in the centre, continuous with that in the rod, and the others, I, I, communicating with the base of the cylinder, A. All are opened or shut at the same time, by turning the plug, E. The cylinder cap, F, is provided with a central valve, the conical end of which enters the rod C at H. The piston and valve stem are furnished with the usual stuffing box packings. When the plug E is closed the cap F may be removed, the piston forced down, and the cylinder charged with grease: then by replacing the cap, setting the valve close into its seat, and the plug opened, steam enters the openings I, I, pressing against the bottom of the piston and forcing the grease, the amount of which passing from the cylinder A may be regulated by the valve G.



The piston is forced back usually by atmospheric pressure, the steam beneath it condensing when the plug is closed. The water of condensation runs back through I, when the lubricator is in use, vertically, or may be drawn off by cock at K.

A composite grease is used in this apparatus, the components of which we cannot here name; it is of the consistency of lard, and is therefore easily transferred to the cylinder, and is readily reduced to a liquid by the heat of the steam conducted through the mass of the piston and cylinder. J. H. C.

New Hydrostatic Gas Press.—Those who have experimented with the oxy-hydrogen light in connection with the stereopticon, gas-microscope and polariscope, have felt the necessity of a more durable, effective and convenient mode of applying the pressure upon the gases, than that ordinarily used. The new Hydrostatic Gas Press fulfils these requirements, and is designed as a substitute for other modes of producing the necessary pressure. It is an application of the well understood principle, that the pressure of water depends upon the height and not upon the quantity of water. The instrument to make this force available is represented in the figure, and an explanation of its modes of operation is here given. It consists of two cylinders, each with two orifices and an elevated water reservoir.



A and B represent the cylinders constructed either of copper or iron, and sufficiently strong to sustain, at a maximum, twenty pounds to the square inch. The lower orifices are for water, and are so arranged that it can flow in or out, as the operator may desire. The upper orifices are for the inlet and outlet of gas. H and E are connected with the jet, and F and G are used for filling the cylinders with gases. The cylinders are first filled with water by opening C, P, and O; the air escaping through F and G. When full, C, P, and O are closed. A is filled with oxygen by connecting F with the wash bottle of the oxygen generator; while the gas is entering, O

and D are open to permit the water to escape. The water gauge, made of glass, on the side of the cylinder, indicates the amount of of gas. O is closed when the cylinder is full.

The cylinder, B, is filled with illuminating gas or hydrogen in the same manner. The vessels being filled with gases, the stopcock D, in the outlet pipe, is closed, and the apparatus is ready for experiment.

The manipulation then consists in turning the stopcock C in the water inlet pipe, which should be done about half an hour before igniting the gases at the jet, to allow the gases to be condensed; as the water flows into the cylinders the gases are pressed upward, and forced through H and E to the jet. The reservoir R, when permanently arranged, should be supplied with a float stopcock and kept constantly filled with water. The pressure upon the gases will depend upon the elevation of the reservoir above the cylinders. A height of ten feet will give about five pounds to the square inch; twenty feet, ten pounds, &c. The amount of pressure upon gas bags rarely exceeds half a pound to the square inch, which can be obtained with the reservoir one foot higher than the cylinders. The reservoir may be dispensed with, and the water inlet pipe be connected with the city water pipes. This answers admirably, but is not so uniform as the reservoir. The portable form of this apparatus should be so constructed that the cylinders can be placed into the reservoirs.—J. G. M.

Telegraphic Possibilities.—A late number of the *Engineer* gives a refreshing collation of the possibilities of telegraphy on the completion of the Russian-American telegraph line.

A telegram from Alaska for New York, leaving Sitka, say at 6·40 on Monday morning, would be received at Necoleaf, Siberia, at six minutes past one on Tuesday morning; at St. Petersburg, Russia, at three minutes past six on Monday evening; at London, twenty-two minutes past four on Monday afternoon; and at New York, at forty-six minutes past six on Monday forenoon. Thus, allowing twenty minutes for each re-transmission, a message may start on the morning of one day, to be received and transmitted the next day, again received and transmitted on the afternoon of the day it starts, and finally reaches its destination on the forenoon of the first day—the whole taking place in one hour.

Directional Rain Gauge.—At the last meeting of the Philosophical Society of Glasgow, Mr. James R. Napier described a

new form of gauge, erected at Shandon, on the Gareloch, for discovering the wet winds, and the amount of rain they have produced. In meteorological observations these results are arrived at by means of expensive self-recording apparatus, not always reliable. Where private registers of rainfall are kept, the direction of the wind is not known with any certainty except at the times of observation. In the gauge described, the rain which falls during given winds is received into one or more of eight vessels surrounding it. If it rains while the wind is from the north, or between the N. W. and N. N. E., the north vessel receives it; if from the N. E., or between N. N. E. and E. N. E., the north-east vessel receives it, &c.; and the total amount of rainfall during all the wind's changes, is in one or more of the eight vessels, to be recorded when the observer pleases. The principle of the gauge is simply that of an ordinary rain gauge, very delicately balanced on a pivot, with a vane attached to be turned by the wind, and a spout of sufficient length to deliver the rain into surrounding vessels. To prevent the angular motions of the gauge from greatly exceeding those of the wind, a weight, balancing the vane, &c., is suspended as a pendulum close to, but not touching, a fixed ring surrounding it, as in Sir William Thomson's "governor." When the gauge turns suddenly or otherwise, the friction then produced between the weight and fixed ring by the centrifugal force due to the turning controls the angular motions. The measurement from the eight vessels may be by the usual graduated glass measure, but a tin measure, having a hundredth part of the area of the gauge, with a solid wooden piston or plunger, of nearly the same area, has been found to give by the sense of touch the amount of rain within three one-thousandths of an inch.

Itacolumite (Articulite).—The attention of scientists have recently been again directed to the structure of this singular, flexible rock, by an article in the *Chemical News*, from the pen of Prof. A. M. Edwards. The labor of Prof. E., of which the article in question is a summary, was undertaken mainly to examine and confirm the results obtained in 1867 by Prof. C. M. Wetherill, after a microscopic examination of the rock. The last named investigator determined the flexibility of the Itacolumite to be due to "small and innumerable ball and socket joints, which exist throughout the mass of the stone very uniformly," and proposed for it the name of "Articulite." Prof. Edwards' examination resulted unfavorably to this view of the subject, and it is in reply to his paper, above re-

ferred to, that Prof. Wetherill publishes another note on "Itacolumite," of which the following is an abstract:

In respect to the joints, it may be said that

(1). Each ball and socket does not admit of a great play, and is not smooth and perfect like that of the joint of a limb; it is, notwithstanding, perfect in principle of motion. The stone is built up of grains and congeries of grains loosely coherent, and forming irregular cavities in which are engaged projecting parts of other congeries or grains of sand, which are susceptible of a slight motion in the cavity—in some cases in one direction, and in others in several or in all directions. This freedom of motion is of the true quality of a ball-and-socket joint.

(2). The motion is *not* most "marked in a direction at right angles to the lamination." It is certainly so if a piece be taken of which the thickness is small in proportion to the other dimensions; but that is not the method by which the true motion is shown. A properly made section is susceptible of as much motion in the plane of lamination as at right angles to such a plane.

(3). The proof of the nature of the joints does not rest solely upon the microscope, although that alone is sufficient. The motions of the cylindrical rod afford an independent and equally convincing demonstration of the ball-and-socket character. There is no other kind of joint which could explain the motions of which this rod is susceptible, viz:—"It can be *compressed* and *elongated* in the direction of its axis, the extent of motion being a little over $\frac{1}{2}$ m. m. When one end is fixed, the other end may describe a circle of 34 m. m. diameter, and may be made to *touch every point in the area of the approximate spherical zone.* The rod can also *be twisted about its axis*, the torsion being 10°. I may add that, by shaking the rod near the ear, one may hear the clicking of the joints as the motion is arrested at the limit of their greatest play.

The nature of the curve (nearly a catenary) when the rod is supported by its ends, agrees with the joints which I have described, and confirms also the revelations of the microscope.

I have never seen anything so wonderful as this rod of itacolulite. When held by one end upward, it totters in all directions, so that no one, seeing it at a short distance, believes that it is a stone. A gentleman from California, to whom it was shown, suggested jocularly that it would do well to build houses with in his earthquake shaken State. Indeed, I have no doubt that a sufficietly high

and thin well built wall would be susceptible of a decided motion before cracking. The height of wall, so much greater than its thickness, would permit the play of the innumerable small joints existing from the bottom to the top, to be perceived.

In order to see the joints, a thin section, supported at one end or at both ends, may be moved while under the microscope with a needle point; by changing the position of the section, a part may be reached at which the play of the joints may be perceived. They can also be seen by *dissecting* a flexible piece of the mineral, using either a fragment or a surface rubbed flat. The surface to be examined is inverted, tapped, and, as far as practicable, brushed free from loose grains. It is then examined under the microscope with a power of 40 to 60 diameters.

The attention of the observer is first attracted by the irregular pits or depressions formed by grains of sand. By very delicate touches with a fine curved needle point, the surface may be investigated; loose grains of sand are seen and removed. Touching other grains and congeries of them delicately with the needle, proves that some have motion in a cavity formed of grains of sand and cemented together. These are dissected out, and other movable groups are found. Some have less motion than others, and some are immovable. By patient investigation of the mineral in this way, the observer will rise satisfied that it is made up of joints of the character which I have described.

A New Pyrometer.—In a paper read before the French Academy, M. Lamy describes a pyrometer of peculiar construction, a condensed description of which will be found below. The instrument is a practical application of the phenomenon first noticed and described with numerous experiments by M. Saint-Claire Deville, and by him termed *Dissociation.* This phenomenon is simply that certain gaseous or volatile compounds, on being subjected to an increased temperature are partially and progressively decomposed to an extent dependent upon the temperature, and, moreover, that the tension of the elements of the mixture; or, as its discoverer termed it, the tension of dissociation increases, but is constant with any given temperature. M. Debray extended this fundamental law to sold substances, which consist of a fixed and a volatile constituent: as carbonate of lime.

In this particular instance, the tension of dissociation can be exactly measured. Heated in vacuo to 860° (C.), it decomposes itself

to an extent that the maximum tension of the disengaged carbonic acid equals 85 mm.; heated to 1040° the evolved gas acquires a pressure of 520 mm.

Just as water evolves a vapor, which for a certain temperature possesses a constant or maximum tension, so also the carbonate of lime, only at a relatively much higher temperature, evolves carbonic acid until, for this temperature, enough is disengaged to exercise a certain constant or maximum tension; and as with water the tension of its vapor increases with the temperature, so also does the tension of dissociation of the carbonate; and, finally, as a decrease in temperature, causes the partial condensation of the confined water vapor, so also does it bring about the partial absorption of the carbonic acid by the lime, so that soon the tension of dissociation, like that of aqueous vapor, will have fallen to a value which is constant for the altered temperature.

Upon this principle the simplicity and practical working of the lime pyrometer of M. Lamy will be readily comprehended.

It consists of a porcelain tube glazed without and within, which is closed at one end, and attached at the other to a two-armed glass tube containing mercury, or to any other manometrical system.

The porcelain tube is provided with powdered calcite or with pure marble, as far as it is exposed to the fire, and is then completely filled with carbonic acid by heating the marble to redness. When the tube returns again to its ordinary temperature the carbonic acid will have been completely re-absorbed by the lime, and the manometer will indicate a vacuum.

The chief advantages of this form of instrument are (by the author) stated to be its simplicity and the consequent cheapness of its construction, that it demands no calculation of its volume, and that it is not liable, at least during an operation, to get out of order. It can readily be attached to the majority of industrial furnaces, and the manometer can be attached at any desirable distance from the furnace. It is only necessary in practice to determine once for all the various maximum tensions of the gas corresponding to various temperatures.

Erbswurst (Pea Sausage.)—Dr. Dingler informs us in his excellent "Journal" that a cook of Berlin has discovered a process by which a preparation of peas may be kept without souring. The Prussian government has purchased the inventor's secret for £5,555. The Prussian war office has bnilt an establishment at Berlin capa-

ble of producing 25,000 sausages of this preparation daily. It is composed of a mixture of bacon, peculiarly prepared pea flour, onions and other ingredients with salt.

The sausages are sent away in boxes, containing 500 or 600, weighing one pound each, for use in the army. They need only be boiled in water to be ready for the use of the soldiers. The daily ration of one pound is found to be sufficient for each man.

Solar Eclipse of December 22d, 1870.—It may be interesting to those of our readers who are not familiar with the fact, to know that two American parties, under the leadership of Prof. Pierce, Superintendent of the Coast Survey, have been organized to observe the phenomenon in Sicily and Spain. The expenses of the expedition have already been cared for by the liberal appropriation by Congress, of $29,000. Of the two parties into which the expedition is divided, the one to observe in Sicily will be under the direct leadership of Prof. Pierce, while the other will be in charge of Prof. Winlock, Director of the Harvard Observatory.

Journal of the Franklin Institute.—January, 1868.—The demands for sets of the *Journal* have recently been so great as to cause a serious diminution of the stock on hand. Especially does the management feel the want of the number heading this notice. In view of this fact, we are prepared to pay 50 cents for every unmutilated copy of that number which is sent to the Hall of the Institute; and we would respectfully request any of our subscribers who may have a knowledge of the existence and whereabouts of incomplete volumes to aid us in enlarging our stock of the wanting number.

CHEMICAL ITEMS.—Yttrocerite.—C. Rammelsberg.—Berzelius gave the name of yttrocerite to a mineral from the neighborhood of Fahlun (Finbo) which occurs along with gadolinite, topas, tantaliferous tin-stone and fluor-spar in a quartz vein in gneiss. It is massive, of blue or violet color, cleavable along the octahedral planes, harder than fluor-spar, and has a Sp. G. = 3·447.

From the analyses which Berzelius made in the year 1816 it appeared that yttrocerite consists of the calcic, yttric and ceric fluorides. Although the proportion of these elements in two analyses was nearly the same, yet Berzelius left it undecided, whether the whole was a combination or a mixture of fluor-spar with the fluorides of cerium and yttrium.

Some analysis which I have lately made of the yttrocerite from Finbo, make it an independent compound, I obtained

	I.	II.
Lime	47·27	49·32
Cerous oxide	9·35	16·14
Yttria	14·87	
Ignition	2·52	

Berzelius found 47·6—50·0 lime; 18·2—16·4 cerous oxide; and only 9·1—8·1 yttria.

When the atomic weights of cerium and yttrium are taken as 92 and 64, it follows from my first analysis that (Ce. Y) : Ca = 1 : 3, and Ce : Y = 1 : 2, and the whole is—

$$2 \left\{ \begin{matrix} Ce\ Fl_2 \\ 2\ Y\ Fl_2 \\ 9\ Ca\ Fl_2 \end{matrix} \right\} + 3\ aq.$$

Berzelius found Y : Ce = 2 : 3 atoms, and in this respect only do the analyses differ. This is either a consequence of the analytical method, or the proportion in which these two elements occur is variable.

A further examination has now shown that the cerous oxide contains almost one-half of lanthanic and didymic oxides. Moreover, that the material regarded as yttria consists of 30 per cent. of an earth precipitable by baric carbonate, and of 70 per cent. not precipitable. I have not penetrated more deeply into the nature of these little known bodies. Mosander found in yttrium three elements, yttrium, erbium and terbium. Bahr and Bunsen have endeavored to show that there are only the two first. Delafontaine declares the first opinion correct, but declares that the erbium of Bahr and Bunsen is identical with the terbium of Mosander. According to this chemist yttrium is not precipitated by baric carbonate, shows no absorption lines in the spectrum and has the smallest atomic weight, 58—60. The oxide is white and the basic nitrate also. On the contrary, erbium (Mosander, Delafontaine) is near 79, gives a yellow oxide, but no spectrum reaction. The terbium, finally, the atomic weight of which is highest, about 112, gives a red oxide, becoming green on ignition and a reddish basic nitrate. The substance regarded by Bahr and Bunsen as erbium shows peculiar spectral lines.* A. R. L.

* Ber. der deutsch. chem. Gesell. Vol. III., No. 16.

Civil and Mechanical Engineering.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from Vol. LX., page 381.)

The Sliding of Belts and its prevention.—"The *Praktische Maschinen Constructeur* affords us an excellent paper upon the above topic, the translation of which reads as follows:

"The most convenient and least expensive mode of transmitting power consists, undoubtedly, in the use of belts. Nevertheless, this system, owing to the sliding of the belts, is connected with a great loss of power that is seldom observed. Let us suppose two corresponding pulleys, of the same diameter, in motion at a moderate velocity. In case the tension of the belt is sufficiently great, and the pulleys not too small, it may be difficult at first to perceive the sliding of the belt; but if the rotations of both the pulley and the belt are counted, a difference in their number will, in nearly all cases, be discovered, the belt performing a less number of rotations than the pulley. We thus become aware that the belt slides upon the smooth surface of the pulley, owing to the fact that the power sought to be transmitted by the belt is greater than the friction of the leather upon the iron, and that this power overcomes the friction, more or less slowly, according to the circumcumstances of the case. In regard to this, it is self-evident that the velocity and diameter of the pulleys must be taken into account, for the friction is more easily surmounted at a rapid velocity than at a slow one, and pulleys of large diameter offer to the strap more surface, and this increases the friction. The consequent sliding of the straps takes place the more easily the greater the peripherical velocity, and the power to be transmitted, on the one hand, and the smaller the diameter, and the breadth of the driver or pulley on the other.

"The sliding of the belt, however, represents a loss of power and fuel. Supposing that the two corresponding pulleys, of equal diameter, the turning one makes 100 rotations in a minute, and the

turned one 95, there will be a loss of nearly five per cent. of the amount of force generated by the motor.

"It will become clear why the loss amounts to not quite five per cent. when it is taken into consideration that in sliding there will be a surplus of the transmitted force over the frictional resistance of the belt, which will be expended in the removal of the friction. This may be most easily recognized when we have a very considerable transmission of power, and when a perceptible sliding occurs, as, for instance, in driving a hydraulic press. If the pressure upon the piston of the pump is much greater than the friction of the belt upon the drum, the former is stopped in its motion, while the belt runs around the driving pulley, the motor itself thereby attains an accelerated velocity, from which it follows that the force required to overcome the friction is less than the one necessary for the working of the hydraulic press.

"In order to ascertain this loss of power for all cases, numerous and extensive experiments had to be undertaken. It may be stated here that this loss may amount to as much as twenty per cent., according to the circumstances. It may appear, at first, that the best means of guarding against this loss would be to construct the pulleys, in regard to diameter and width, so that the resistance of friction could not be overcome by the power transmitted. Nevertheless, upon a closer examination, it will become evident that this can, in most instances, only be accomplished at great expense. The outlay for leather belts is already considerable in an establishment of medium size, and would be still greater if all the belts were to be taken of such a width as is necessary for the prevention of sliding. Other means have, therefore, been proposed and applied. For instance, an endeavor was made to increase the friction of the leather upon the iron by spreading pulverized rosin or asphaltum upon the belt. In instances where the latter ceases to draw, the effect shows itself at once: but, nevertheless, only for a short time. On account of the pressure, the resinous powder penetrates the belt, so that its surface soon becomes as smooth as before, while the leather soon gets brittle and is gradually destroyed.

"The covering of the pulleys with wood is less objectionable, but it can find only a limited application. Only a wide pulley can be lined in this manner, but as the wood soon gets as smooth as the iron, it is necessary to roughen its surface repeatedly. This brings

about a change in the diameter of the pulley, as well as in the amount of force transmitted.

"A third preventive, which seems to have found extended application, consists in giving to the pulley a convex surface. But whether this prevents the belt from running off is yet to be proven. The writer has ascertained, that in consequence of the convexity of the drums, the belts will be stretched more in the centre than at the edges, and that as the frictional surface thus becomes smaller, the danger of sliding is increased.

"The covering of the pulleys with leather is undoubtedly the more advantageous, as thereby the frictional resistance is increased; the co-efficient of friction of which, with the leather, is considerably greater than that of the leather upon iron. The latter amounts to 0·25, the former to 1·25, which is just five times more.

"The resistance of friction may, nevertheless, be greatly increased by roughening the leather lining and keeping it thus by means of an alum or salt solution. The great benefit to be derived from this system has been demonstrated by practical tests.

"We give some of the results of the new system. A spinning-machine was made to produce, continually, a uniform thread, while by the sliding of the belt, it produced a thread containing knots and unequal spots. Ventilators which made only 1100 rotations per minute, in consequence of sliding, made 1400 after sliding was prevented. In a steam mill, with five run of mill-stones, each set ground 27 bushels per day after the pulleys were covered with leather, while before the amount ground per day was only from 23 to 24 bushels. Moreover, the troublesome falling off of belts, which previously occurred very often, ceased altogether. In a paper mill, a rag engine did fifteen per cent. more work per day after its pulleys were covered with leather. In sugar mills, for the beet crushers, the centrifugal and other apparatus, this system has been fully approved, and it cannot be doubted that it will be of advantage wherever introduced. It may be remembered that leather may also be used in establishments where the power is transmitted by wire-ropes. It is, in such cases, preferable to wood, cork, asphaltum and gum.

"The reason why the belts last longer is to be attributed to the fact that the increased friction allows a lesser degree of tension of the belts than would be the case if they were to run on a smooth iron surface. It is well known to every machinist, that for great

transmissions of power, the belts, if running on an iron surface, must be stretched to the utmost limit. This may be regarded as one of the causes of the rapid destruction of the leather.

"The same result is brought about sooner from the circumstance that, on account of the friction, fine particles of iron are detached, which, by combining with the tannic-acid and the fatty acids in the leather, form compounds, which, by penetrating the leather, cause the same to become brittle. By covering the pulleys with leather, this evil is prevented. But the chief cause of the rapid destruction of the leather is to be attributed to the sliding itself, which, as before mentioned, represents a useless loss of power. By the friction of the leather upon the iron, heat is generated, which causes what is called the 'burning' of the leather.

"Therefore, by running belts upon smooth iron pulleys, not only the power to be transmitted acts destructively upon the leather, but other causes also, which is not the case when leather-band wheels are employed. The application of leather to the wheel is very simple and easy, and may be done by means of glue by any intelligent workman."—*Technologist*, Nov., 1870.

From *Leonard's Mechanical Principia* we make the following extracts:

"If the power to be transmitted exceeds 20-horse, and circumstances will not allow the centre of the drums to be over 15 feet apart, the power should be transmitted by gearing."

A table is given which is based upon the following data:—One horse-power is transmitted by belts, 1·8, 1·2, 0·9, 0·72, 0·6, 0·514, 0·45, 0·4, 0·36 inches wide if carried over pulleys 2, 3, 4, 5, 6, 7, 8, 9, 10 feet diameter respectively, at the velocity given above.

"It is immaterial whether the smallest drum is the driving or the driven drum; if the diameter of the smallest drum remains constant, the width of the belt will remain constant; if the diameter of the other drum should be increased indefinitely."

From *Spon's Dictionary of Engineering*, p. 312, we take the following:

"Belts and drums form very effective friction-couplings. If a machine driven by a belt becomes accidentally overloaded, the belt slips upon the drum, and a break down is generally prevented. By the introduction of fast and loose pulleys the driven shaft can be set in motion or stopped with perfect safety, whilst the driving shaft is running at full speed. The motion of belts and drums is

much smoother than that of gearing, and they can be readily applied to machines which require a high velocity, where ordinary gearing would be quite inadmissable.

"The best description of leather for belts is English ox hide tanned with oak-bark by the slow old-fashioned process, and dressed in such a way as to retain firmness and toughness, without harshness and rigidity. The prime part of the hide only, called the *butt*, should be used; these are cut out of hides in the preliminary preparing process, and tanned by themselves, afterwards stretched by machinery and allowed to dry while extended. Strap-butts of best leather can be permanently elongated 4 to 5 inches.

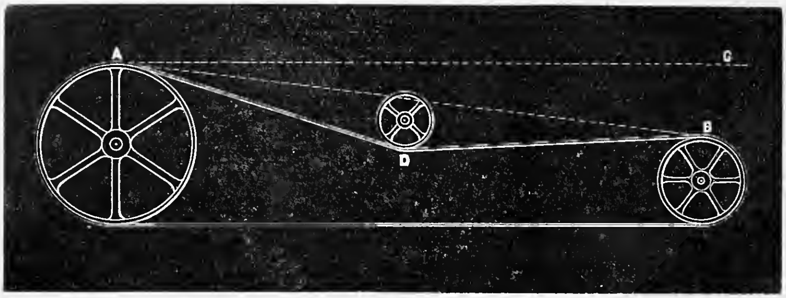
"For light work, belts of single substance are sufficient, the strips of leather being joined together by feather-edged splices, first cemented and then sewn. Single belting varies in thickness from $\frac{3}{16}$ to $\frac{1}{4}$ inch. For heavy work, double and sometimes treble layers of leather are required, cemented and sewn through their entire length. The material used for sewing is either strong, well-waxed hemp, or thin strips of hide prepared with alum. The latter is generally used in the North of England; but its advantages over good waxed hemp is doubtful. The thickness of double belting is from $\frac{5}{16}$ to $\frac{7}{16}$ inch.

"An improvement in the ordinary double belt has been introduced by Messrs. Hepburn & Sons, of Southwark, who have given much attention to this branch of leather manufacture. It consists in the use of a corrugated strip of prepared untanned hide for the outer layer of the belt, and the usual tanned leather for the inner layer, rivetted together by machinery. The rivets are made of copper or malleable iron, and have their ends spread, bent and driven in flush with the surfaces of the layers. Metallic sewing of this kind is also applied to double belting made entirely of leather, and has been found to work well, and is more durable than ordinary hand-sewing.

"The drum should be $\frac{3}{16}$-inch per foot of width, rounding except in the case of small high-speed pulleys, which should be $\frac{3}{8}$ to $\frac{1}{2}$-inch.

"In order that the natural tension of the belts shall remain constant, and not exceed, though equalling the value calculated, it is requisite to use *tension rollers*. The weight, W, of these rollers is found by the approximate expression, $w = \frac{2\ \text{T} \cos. a}{\cos. b,}$: wherein a is

half the obtuse angle A D B, formed by the belt upon which the weight rests, and may be assumed *a priori;* b the angle between the line A B and the horizontal line A C: that is, the angle B A C = b , and T = tension on tight side.



"In fixing the belt, care must be taken to give it such a length that, when at repose, it shall only have a minimum flexure."

(To be continued.)

THE ALLEN ENGINE.

By Charles T. Porter.

(Concluded from Vol. LX., page 387.)

Lubrication.—Careful attention has been given to this subject. The valves and cylinder are fed by the displacement lubricator shown in the plates, and which is fixed on the steam-chest. To fill it, the plug at the top is unscrewed, the steam having been shut off from it, if the engine is running, and the water is drawn off with a siphon tube. The lubricator is then filled to the top of the central tube with melted suet, and the plug is replaced and steam turned on. The steam continually condenses in the space above the liquid surface, and the water formed sinks through the suet, causing the latter to overflow and pass down the tube. At the end of ten or twelve hours it will be found to be, perhaps, half gone, and should be filled as above. This lubricator admits of no other attention, and, as everywhere in this engine, the continuous and uniform action insures excellent lubrication, with the greatest economy.

The guides are oiled automatically by the arrangement shown in Plate I. The wicks can not be pushed down far enough to be

caught by the cross-head. The oil is taken from the upper [illegible] passes by four passages through the body of the cross-head, and is distributed over its lower surface. These need no attention, except to see that the wicks are in working order.

The crank-pin is fed by a novel device, perfect in its action, and which completely removes the most serious difficulty that has been encountered in running engines at a proper speed. This arrangement, and the course of the oil, are shown in Figure 1, Plate I. The lubricator is fixed on the pillow-block, and the oil is taken from it on a plate called a radiating-plate, which is attached to the crank, and the crowning surface of which, touches the end of the wick at each revolution. The oil on this plate takes the radial motion, and is led directly to the surface of the crank-pin.

The engineer can, while the engine is running, observe the action of this lubricator, refill it, adjust the wick, or supply additional oil to the pin by dropping it on the tube. If the passage becomes obstructed from using bad oil, a little weak lye will clear it, changing gum into soap.

The eccentric is oiled in a similar manner. The cross-head pin is fed by a wick from a cup set over the guides. A bridge in the enlarged end of a tube is so placed on the connecting-rod that it rises to touch the wick at the beginning of each forward stroke.

This system of lubrication enables these engines to be run continuously for any length of time, and with only the attention necessary to refill the lubricators and oil the valve gear; while the action of the lubricators is not liable to derangement from the motion of the engine, however rapid this may be.

Economic value of a higher piston-speed.—The chief claim of this engine to the position of excellence rests upon its superior economy of steam. While exhibiting, perfectly, every economic feature which is found in the best slow-running engines, it possesses an additional important element of economy in its speed. The advantage, in this respect, which higher speed confers is easily explained.

The loss in the steam engine, which expansive working cannot diminish, but, on the contrary, tends to increase, is that which arises from condensation of the steam while being used. Steam is only the medium for the conversion of heat into mechanical work: but, before this conversion can be effected, a large proportion of its heat is liable to be lost. This loss is not, except in a trifling degree, from external radiation; it is internal, and arises from the enor-

mous facility with which water, and especially the vapor of water, abstracts heat from, or imparts it to, bodies in contact with it, which are warmer or colder than itself.

Steam, on account of the perfect mobility of its particles, and the velocity with which these impinge against the surfaces exposed to them in an engine, keeps the temperature of these *surfaces* very nearly identical with its own, however suddenly or extremely this may be varied.

The action, during one revolution of an engine, is this: At the commencement of the stroke, and up to the point of cut-off, more or less water is present in the cylinder. Let it be supposed that, at the point of cut-off, the temperature of the steam, of the water present, and of the surfaces of the cylinder, piston, and cover is 320°, which is the temperature of steam, and the boiling point of water, under a pressure of 75 pounds on the square inch, above the atmosphere; and that the cut-off takes place at such a point in the stroke that the pressure will, by expansion, fall from the above pressure to that of the atmosphere, at the end of the stroke. Simultaneously, the temperature and the boiling point fall 108 degrees, or to 212°, and will remain at this point through the return stroke.

During the expansion and the return stroke all the water present is evaporated, and passes with the exhaust into the atmosphere, as steam, provided the large amount of heat necessary to effect this change of state can be abstracted from the metal. Then, at the commencement of the next stroke, an equal portion of the entering steam is condensed to restore this heat, which the very water formed by such condensation will, when relieved from pressure, immediately rob from the metal again, by reëvaporation, and carry into the atmosphere; and so at every stroke the ceaseless waste goes on.

The water which, to impart heat to the cylinder, piston and cover, was condensed from the entering steam, as a dew upon their surfaces, in reëvaporating during the expansion and the return stroke, instantly cools these *surfaces* nearly to its own reduced temperature. But the mere surfaces can supply no appreciable amount of heat. It must be brought from the interior of the metal by conduction, and this requires time. Therefore such evaporation is a gradual operation, and not an explosion, and the condensation of the entering steam is partial, and not total.

Time is the necessary condition without which this wasteful action cannot take place, and the extent to which it proceeds, is, other

things being equal, directly as the time allowed. Mr. Isherwood was able, by running the engines of the steamer Michigan very slowly, to more than neutralize, in this manner, the gain from a high grade of expansion, and to show instead, a serious loss.

If the piston of an air-gun is slowly pressed down, only a slight increase of temperature is shown in the chamber; but if this is done smartly, heat is developed which will ignite tinder. Now, the same work is converted into heat in each case, only in the last one very little time is allowed for the metal of the chamber to conduct it away. So in this engine the sudden compression at the end of the stroke develops heat; the rapid action allows but little time for this heat to be diffused through the metal, and it is mostly or wholly available to prevent the condensation of the entering steam. The more the subject is examined, the more obvious it will appear that, as only time is necessary for *all* the heat contained in the steam to be lost; so, on the other hand, rapid speed of piston is an important means of its economy.

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

By Col. O. W. Childs, C. E.

(Continued from Vol. LX., page 395.)

The average annual fall of rain and snow, in the State of New York, during the period of ten years preceding that of 1846, as appears from the annual Report of the Regents of the University for that year, is 34·14 inches, and the greatest fall in any year, during the same period, was 37·04 inches, and the least 32·10 inches.

Although the aggregate fall of rain in the month of May, 1850, as appears from the above statement, was 9·14 inches, there was no sensible rise in the river or lake until the 5th of June. The quantity of water that passed from the lake when at its greatest depression on the 4th of June last, as ascertained from a careful guage of the river at its minimum flow, was 11,930 cubic feet per second. The flow in the San Juan, immediately above the junction of the San Carlos river, as guaged on the 15th of July, was 19,300, in the San Carlos at the same time 16,547, making the whole quantity flowing in the San Juan, below the San Carlos, 35,747 cubic feet per second. On the 8th of August, the quantity passing in the San Juan, above the Serapiqui, was 39,526, and in the Serapiqui 13,266, giving to the San Juan, below the Serapiqui, 52,792 cubic feet per second. The flow in the San Juan, immediately above the Colorado, as guaged on the 20th of August, was 54,380 cubic feet

per second, of which 42,056 passed through the Colorado branch to the ocean. and 12,324 through the San Juan. Subsequently to the 5th of June, the river was more affected by rains, and on the 19th September, at the taking of the last observations previous to leaving the country, the lake was found 2·55 feet above its lowest stage, or the level it occupied the preceding May; it probably continued to rise until the following November, the usual termination of the wet season. Owing to the subsequent rise in the river, the above quantities were correspondingly increased to those given in a preceding table.

The lake fell from its greatest elevation on the 23d December, 1850, to its lowest, on the 27th of April, a period of 125 days, 3·43 feet, and continued about at this latter stage to the 5th of June.

The quantity discharged from the lake, when elevated 343 feet above its lowest stage, as estimated from the guages, is 18,059 cubic feet per second, and allowing the discharge gradually to diminish to 11·930 at the end of the above 125 days, would give a mean flow for this period of 14,995 cubic feet per second, or 899,700 cubic feet per minute, from which deduct the amount before shown to be required for the canal, 105,130, and it gives 794,570 cubic feet per minute, or for the whole period of 125 days, 143,022,600,000 cubic feet as the quantity that passed from the lake, in excess of that required during the same time for the canal. If the average of the area of the lake be taken at 110 miles in length by 25 in breadth, which probably would not vary essentially from the truth, this quantity in passing from the lake reduced its surface 1·87 feet, which, deducted from 3·43 feet, the whole fall, leaves 1·56 feet as the amount of its reduction by evaporation, in which is also included the whole supply of drainage from the surrounding country during the same period; thus showing, that it will be necessary to commence at the close of the wet season, with an excess of surface elevation of the lake, of 1·56 feet above that which it must necessarily have at the close of the dry season, an amount that may very readily be held in reserve, and the flow regulated by means of gates on the crest and in the body of the dam.

It is not known that this would to any very great extent prove injurious at any locality: between the Castillo and Toro Rapids, some lands would be flowed that would otherwise be susceptible of cultivation; the immediate valley being narrow, the amount that would be thus occupied by water is quite small.

Between the Toro Rapids and the lake, the low flats lying between the river and upland, occupy a large portion of the distance, and alternately varying from a few rods on one, to say half a mile on the opposite side in average width, and having an elevation varying from 1½ to 2½ feet above the surface of low river, they are entirely submerged during most of the wet season, and are principally covered with an aquatic plant, of a light spongy texture, known as the Coroza, a species of wild palm, growing some 30 or

10 feet in height. These wet lands have now no value, and were they permanently flowed to the depth contemplated, the facilities for communication between the river and upland by boats in the channels of the lateral streams, would be improved, and the atmosphere rendered more healthy. The banks bordering the sides of the lake, so far as observed, are sufficiently high, and whatever may be their elevation at other places, it is not perceived that injury could result from continuing the surface of the lake at the elevation it now occupies so large a portion of the year. It is certain that no improvements would be disturbed, and the means of access at numerous points on the lake for purposes of commerce, would probably not be impaired.

No land worthy of note would be flowed by dams from Nos. 2 to 7 inclusive; the country along the river is hilly and the banks are generally elevated above that of the level, to which it is proposed to raise the water by these dams.

In the preceding table before given, of inclination of surface, &c., the inclination of that portion of the river above the Toro Rapids is stated at 0·12 of a foot per mile; this multiplied into the length in miles of that portion of the river, gives 3·26 feet as the inclination of its surface in time of maximum flow, an amount that would be too great to admit of a convenient control of the flow from the lake, by means of the Castillo dam. It should be stated, that in the calculation of all the inclinations and velocities given in the table, no allowance is made for enlargement of volume by a flow beyond the immediate channel of the river. In the case under consideration, this enlargement will be quite sufficient to bring the inclination within such limits as will render the flow from the lake perfectly controllable by the method before stated, aud usually adopted in such cases.

Capacity of the Canal.—From information obtained from the most popular builders and others skilled in the science of the model and tonnage of steamers and other vessels, the opinion is ascertained, that steamers of from 1,800 to 2,400 tons, and merchant sailing vessels of a somewhat greater burthen, may be so constructed as to be well adapted to the passage of the locks, for movement in the projected canal and for sea service. The former in navigating the canal would be propelled by their own power, and the latter would necessarily be tracked by steamers, especially constructed for that purpose, excepting that portion west of the lake, and on that inland, between Dam No. 7 and the harbor of San Juan del Norte, where, owing to the additional delays that would be caused by a propelling steamer in passing the locks, animal power might probably be used with more advantage. The canal would also probably be navigated by brigs, and other coasting vessels of a smaller class, which, if admitted, would of course reduce the movement of the maximum tonnage, of which the canal would otherwise be capable.

The average time required for steamers and other vessels to pass

a lock is estimated at 24 minutes, or 60 per day—the steamers requiring something less, and the larger class of sail vessels a little more than that above stated.

The average rates of speed with which the steamers may safely move in the inland portions, without injury to the vessel or the banks of the canal, is estimated at two and a half miles per hour, on the river portions seven miles per hour, and on the lake the same speed may be attained as on the ocean, say eleven miles per hour. Sailing vessels propelled by horse power might move on the canal at the rate of two miles per hour, and by steam-tugs in the river and lake with an average speed, of say four miles per hour.

The time, then, occupied in making a passage from ocean to ocean, in hours, would be for the steamers

47·09 miles of canal navigation, at the rate of $2\frac{1}{2}$ miles per hour.	18·83
90·80 miles of river navigation, at the rate of 7 miles per hour,	12·97
56.50 miles of lake navigation, at the rate of 11 miles per hour,	5·14
Passage of 28 locks, at the rate of 20 minutes per lock,	9·33
Total,	46·27

say two days.

Time occupied by Sail Vessels.

47·09 miles of canal navigation, at the rate of 2 miles per hour	23·54
147·30 miles of river and lake navigation, at the rate of 4 miles per hour,	36 82
Passage of 28 locks, at the rate of 30 minutes each,	14·00
Passage of 8 locks by steam-tugs, at the rate of 20 minutes each,	2·67
Total number of hours	77·03

or, say $3\frac{1}{4}$ days.

The establishment of lights at several points on the river, and at the cuts on either side of the lake, in addition to those required at the locks, will be indispensable to a practicable navigation in time of night.

The improvement of rivers above tide water, for purposes of navigation in connection with that of inland canals of ordinary dimensions, is, except under peculiar circumstances, regarded with disfavor. The objections to adopting the channel of a river as part of a canal, arise mainly from the presence of a too great current in time of flood, and the difficulty and expense attending the repairs of the mechanical structures connecting the inland with the river portions of the navigation. On the San Juan river the former will, to a great extent, be remedied by the large increase of volume produced by the dams on the river below.

In cases of substituting rivers for inland canals of large dimensions, where high dams are practicable, the double advantage of saving the expense of constructing a large prism, and of avoiding excessive currents, is attained, and the navigation of the river portions with steamers, and with sail vessels tracked by steam-tugs, would be more practicable; these advantages will, to a very great

degree, be realized by the adoption of this river upon the plan projected; although the substitution of an inland canal might by some be considered practicable, the expense, owing to causes already stated, would be very great.

It is to be admitted, that high dams are more liable to failure than low ones; the failure, however, in the cases under consideration, being so much reduced by the elevation of the river below them, by succeeding dams in all of the cases of earth foundation, excepting No. 7, very much tends to their security. With the proper precautions in constructing the latter, and ordinary care in the others on the plan proposed, it is believed that these dams can scarcely be regarded as liable to the contingency of serious failure.

Upon that canal, the effects of frost, an agent the most destructive of masonry and other parts of the canals in this country, and to which a large proportion of the sudden breaches that occur may be attributed, will not be experienced; and so far as known, all of the conditions connected with permanency and uninterruptad navigation will be much more favorable than would attend a canal of the same dimensions and character of workmanship, located in this country.

The instructions of your board require the survey and estimates to be for a canal of sufficient depth for vessels of the largest class.

(To be continued.)

IRON MANUFACTURES IN GREAT BRITAIN.*

FIRST PAPER.

By R. H. Thurston, Eng. U. S. N., Assist. Prof. Nat. Phil. U. S. N. A.
Member of the Institute.

Iron shipbuilding, though an art of but little more than a quarter of a century's growth, has become one of the most important branches of British industry, and an essential element of British commercial supremacy.

The advantages of iron over wood as a material for ship construction are so marked and have now become so well understood, that it cannot be long before wooden hulls will have become entirely superseded wherever iron can be cheaply obtained.

Some of these advantages are, greater strength and durability than can be obtained in wood; less weight of hull by, probably, 15 to 25 per cent., as the iron is of less or greater strength; greater facilities for thorough repairs and periodical inspection of every part; greater safety from the admission of transverse bulkheads, and, in

* A professional tour occupying a few weeks of the past summer has furnished a mass of memoranda, from which the material of the following article has been gleaned.

large vessels, the cellular structure of bottom; less liability to general breaking up when wrecked, and less danger from fire. The fine lines that can be obtained in iron, without impairing the strength of the structure, specially adapt iron vessels for screw propulsion; the ease with which an iron war-vessel may be laid up, and her freedom from deterioration for an indefinite period, are most important advantages where the larger proportion of the vessels of a navy are never employed, except in time of war.

All European nations have learned to recognize these advantages; and, in the United States, iron shipbuilding is gradually assuming its rightful position, notwithstanding the cheapness of timber.

The disadvantages of rapid fouling in warm climates, and of the deviation of the compass from local attraction, although less formidable than at an earlier date, are still serious evils. Some one of the numerous paints and other expedients that are almost daily proposed, will probably be found to prevent fouling of the bottom; and the laws governing the magnetism of ships are becoming so well known that this evil is rapidly becoming insignificant.

It can hardly be doubted that, in the United States, the screw colliers recently built of iron on the Delaware, are the pioneers of a large fleet of iron coasting vessels, and that iron steamboats are, sooner or later, to exhibit their special advantages on our western rivers, as the only vessels in which a strong hull can be obtained with light draught of water. It is to be hoped that the value of iron will be soon as well recognized in the United States as it is already in Great Britain.

A very considerable part of the iron shipbuilding of Great Britain was formerly carried on in the neighborhood of London, and near Liverpool, but, after sharp competition, the builders in the North of England, and in Scotland, have almost entirely absorbed the business.

On the Thames, scarcely any of this work is now done; but a very good business is still done on the banks of the Mersey, several firms being established there.

At Lairds' establishment, Birkenhead, nearly all of the five stone docks and four slips were occupied, at the time of our visit, either by new vessels, or by steamers taken in for repairs; they were not, however, employing their full complement of 2,500 men. There may be seen here an unusually fine collection of models, represent-

ing vessels constructed here: among them some of the finest ships in the British navy and mercantile marine, and a considerable number of vessels built to foreign order.* Among the latter was pointed out the graceful model of that costliest of all ships, the "Alabama."

Builders on the Mersey enjoy the advantage of obtaining their coal and iron from the neighboring collieries and mines of Lancashire, and are, therefore, quite well prepared to compete with builders in other parts of the Kingdom: labor is rather expensive.

On the Tyne, the largest establishment is that of the "Palmer Shipbuilding Company," at Jarrow, a few miles below Newcastle. Here may be seen the reduction of the ore in their four great blast furnaces, the puddling and rolling of the iron, and all other processes up to the completion of the iron ship and all of its machinery and fittings; the whole establishment employs about 6,000 workmen. We found here nearly a dozen steamers, in all stages of progress. Several were screw colliers, plainly finished, and of low steam power, but well put together and capable of doing good service; another was a fine large steamer for the Guion transatlantic line, a vessel of beautiful lines, great strength and high power: still another was the British iron-clad "Triumph," since launched. This vessel, like a sister ship, the "Swiftsure," which was some time since completed by the same firm, is 3,892 tons register, 280 feet between perpendiculars, 55 feet beam, $36\frac{1}{2}$ feet from spar-deck to keel; 6 inches of armor is carried over a 10-inch teak backing and $1\frac{1}{4}$ inch inner skin; the battery is in a central casemate; the bow is shaped and strenghtened to be used as a ram. The machinery is built by Messrs. Mandsley & Field, of London; the steam cylinders are 80 inces in diameter, with 4 feet stroke of piston, and steam jacketed; these engines are of the common style direct-acting, fitted with surface condensers, and the steam is furnished by boilers with horizontal fire-tubes. These ships have lifting screws, and carry a large spread of canvas. A peculiarity in the construction of the "Triumph" is the wooden planking covering the iron skin plating below the water-line, which is intended to be coppered over like any wooden ship.

On the Wear and the Tees, and other northern English rivers, shipbuilding is carried on extensively; but by far the busiest spot in Great Britain is found on the banks of the Clyde, near Glasgow. Messrs. R. Napier & Sons, J. & G. Thompson, John Elder & Co.,

* H. M. S. Captain was built by Messrs. Laird: *vide* Jour. of the Frank. Inst., No. 5, Vol. LX.

Tod & McGregor, and other well-known firms, are established here, and almost line the banks of the river from Glasgow to Govan.

During the first ten months of the last year, 156 iron vessels have been launched here, with a total of 144,200 tons burden; during the corresponding months of 1869, the number of vessels was 180, and of tonnage 160,000.

These vessels are almost exclusively steamers, and vary in size from 1,500 up to 3,000 tons register.

The cost of the cheaper class of vessels, capable of making eight or nine knots under steam, is about £16 per ton; of moderately high powers, steamers for passenger lines, £22 to £25; and of first-class passenger steamers of high speed, fine finish and extra fittings, £30 per ton, and even higher.

The systems of work in this and other shipbuilding districts of Great Britain differ slightly in matters of detail, but in all dimensions builders are, everywhere, generally governed by rules approved by either Lloyd's or the Liverpool Committee.* Occasionally, however, purchasers who are able to act as their own underwriters, prepare their own specifications, and, as a rule, obtain even stronger hulls than the rules produce.

The iron put into English and Scotch ships is not usually of the best quality of even British iron, and British ships are not, therefore, as strong as they should be with hulls of such weight; but the workmanship is generally good, and the disposition of butts, and the method of fastening, are such as make the best possible use of the material in respect to strength of structure.

The iron used in Glasgow ship-yards is Scotch iron, made in the neighborhood, and is obtained at prices that are low in comparison with those paid in the South of England. The cost of labor is also very greatly in favor of Scotch builders, the difference between wages here and on the Thames being stated by some builders as from 30 to 35 per cent. The contrast between the activity seen on the Clyde and the quietness on the Thames is, therefore, readily accounted for, and it can hardly be expected that southern competition can again be successful, now that the one necessity that was formerly lacking in the North, skilled labor, is readily obtained.

The most extensive establishment on the Clyde is, now, that of Messrs. John Elder & Co., the "Fairfield Works." Here we found

* For particulars, consult "Shipbuilding in Iron and Steel." By E. J. Reed, C. B., Chief Constructor of the Navy; London, John Murray 1869, an admirable work.

nine steamers on the blocks, and several others were either afloat and proceeding rapidly to completion, or were ready to be laid down as soon as room could be made for them. Work is done here rapidly and well, and the crowded state of their yard indicates that they are fully sustaining a long established and well earned reputation.

The "Italy," of the National Line, was recently set afloat by this firm. An inspection of the steam log of one of her earliest voyages between Liverpool and New York, shows her to have made the run with perhaps the heaviest cargo ever carried across, in twelve days, on less than fifty tons of coal per day; the mean indicated horse-power for the trip was about 2,000. This was, certainly, a very excellent performance for a ship registering 3,700 tons, and proves the vessel to have a fine form as well as excellent machinery.

Messrs. J. & G. Thompson were building two steamers of large carrying capacity, and of moderate power, for grain transportation; they have a square, full midship section, but neatly drawn lines fore and aft, and are expected to steam nine knots per hour. Two steamers for a mixed traffic, carrying both passengers and freight, were also well along, and others were afloat and nearly ready for their owners. Messrs. Thompson built the "Russia" and other later steamers for the Cunard Line, and the fact is a strong testimonial in their favor. About 2,000 men are employed in the engine-shops and shipbuilding yards of this firm.

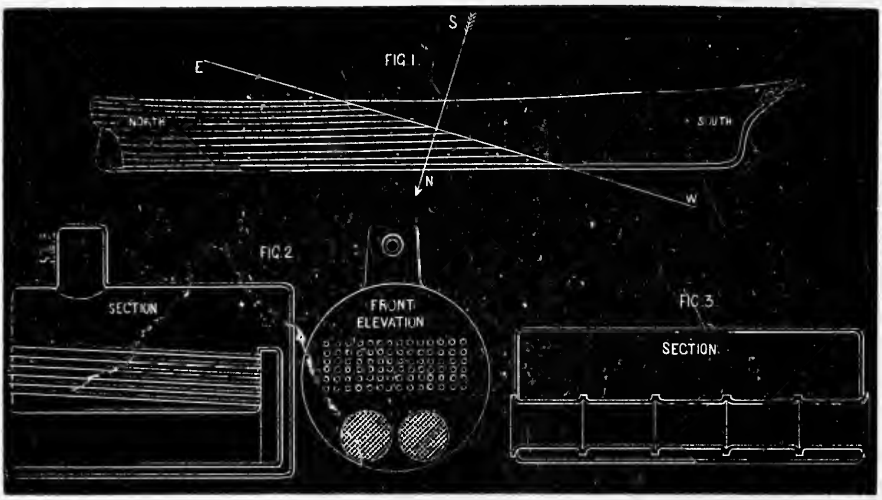
Messrs. R. Napier & Sons, and the other firms of the neighborhood, were moderately well supplied with work, and all appeared to anticipate a still further increase of business. The Napiers have long been well-known as one of the few firms to whom the English gov~~ernment has been accustomed to~~ entrust public ~~work~~. They have recently completed the "Hotspur," a peculiarly designed iron-clad, for the British navy. This ship is intended to be formidable as a ram, and has powerful engines, twin screws, and carries very little canvas; the side armor is from 8 to 11 inches in thickness, and is carried forward to the stem in such a manner as to greatly strengthen the bow; the single heavy gun is carried in a pear-shaped casemate; the ship is of 2,637 tons register. Among merchant steamers, the "Ville de Paris" and "Periere" may be mentioned as fine specimens of Messrs. Napiers' work.

In all yards visited, the keel was laid in the plane of the magne-

tic meridian, with the stem toward the south; the magnetic character assumed by the ship is therefore exhibited by Fig. 1, where N S is the line of dip of the magnetic needle, and E W, the neutral line of the ship; the shaded portions have a north, and the unshaded part a south, polarity.

An iron ship usually acquires, while building, a strong magnetic character, and as a considerable loss of magnetism generally occurs in the first heavy weather that is met with, the first voyage of the ship occasions some anxiety, but the magnetism soon becomes much less in amount and nearly permanent in character; the compensation of the compass may then be effected, or a revised table of errors constructed, and the ship's course can be laid with perfect confidence.

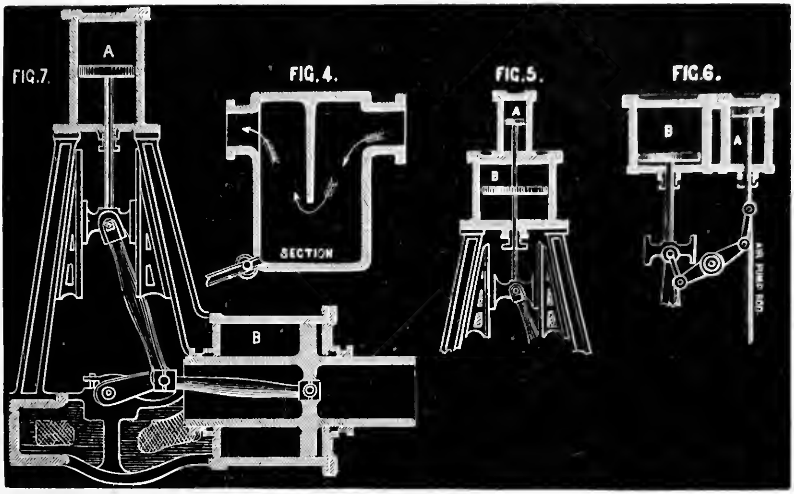
In the examination of this subject, the magnetism of ships and the deviation of their compasses by local attraction, Scoresby, Bar-



low, Rundell, Evans, Airy and a few other theoretical and experimental investigators have rendered the world a service that will never be fully appreciated. Through their labors the compensation of the compass has become comparatively simple, the differing effects of the induced and permanent magnetism being now quite readily distinguished and easily compensated separately.

In the machinery of steam vessels, important changes have occurred within a few years, in consequence of the imperative demand for economy of fuel and space. The pressure of steam carried in marine boilers, has gradually risen with a corresponding increase

in the extent to which expansion is carried, until some of the leading British marine engine builders have introduced boilers in which the pressure of steam is kept at 75 pounds per square inch, and engines in which it is expanded from five to ten times. In some cases, even higher steam and greater expansion has been adopted, Mr. J. M. Rowan, of Glasgow, having run up to 120 pounds and more, per inch, expanding more than 15 times.



The adoption of such high pressures and great expansion in the marine engine, where regularity of motion cannot well be insured by the use of a fly-wheel,* has compelled a radical change in the form of engine. Messrs. Maudsley, Sons & Field attempted, some time since, to introduce an engine in which three cylinders were coupled to cranks set at angles of 120° with each other, but we were informed by a member of the firm that their cost prevented their becoming a commercial success, although quite satisfactory in regard to economy of fuel, and we found that firm, like nearly every well-known firm in the kingdom, building "compound engines." Perhaps the only exception to the rule is that of Messrs. Penn & Sons, who have the finest establishment for the manufacture of marine engines in Great Britain; they still build the trunk and oscillating engines for which they have long been celebrated.

Surface condensation is now universally adopted.

* At least one English line (of China steamers) has adopted a single cylinder engine with fly-wheel, with, it is stated, satisfactory results.

The boiler used for generating high steam is usually very similar to the one shown in Fig. 2. A cylindrical shell of about 7 feet diameter and a thickness of from $\frac{3}{4}$ to $1\frac{1}{4}$ inches, according to the amount of steam carried, is built with two and sometimes three large cylindrical flues, in which are the grates, and above them a set of horizontal "fire-tubes," of about 3 inches diameter and from 6 to 8 feet long, through which the gases return to the front and thence rise into the "funnel." This boiler is strong, of moderate cost, generates steam freely and economically, and occupies comparatively little space. The riveting is performed by a steam riveting machine, wherever possible, butt joints being usually adopted, and the work looked generally strong and neat. The ends of the boiler are strongly stayed, and the tube sheets are stiffened with stay tubes with thin nuts at each end. The flues are often strengthened by ⊥ rings at intervals, and another method, which, however, is oftener seen in land boilers is shown in Fig. 3.*

Between the boilers and the engines, a "spray collector" or "separator," of the form shown in Fig. 4 is often placed, even when the steam has passed through superheating tubes.

In the design of engines, a great variety is noticed, as every builder has his own peculiar style, for which he claims special advantages, but we usually find a general resemblance to the old Woolf engine of seventy years ago.

In the engines built by Messrs. Maudsley & Field, the small high pressure cylinder, A, is placed upon the large cylinder, B, Fig. 5, both having a common piston rod, and two such pairs being usually coupled to cranks set at right angles. This arrangement is very convenient, also, in altering old engines.

Messrs. Elder & Co., formerly Randolph, Elder & Co., who are probably entitled to the credit of having, many years ago, and in the face of immense opposition, been pioneers in the adoption of high steam and considerable expansion with the compound engine, usually so arrange the high and low pressure cylinders that their pistons move in opposite directions, coupling two pairs to the crank shaft.

By this arrangement short passages are obtained between the cylinders and a simple form of valve-gear. The opposite movement of the pistons is sometimes obtained by placing the two cylinders of a pair in the fore and aft line, coupling their rods to cranks set on the crank shaft at 180° apart; in another and less expensive

* This method of strengthening flues was proposed for "Cornish boilers" by the writer some years ago, but purchasers generally preferred to accept a weaker boiler at less cost.

arrangement, one cylinder, see Fig. 6, acts directly upon the crank, while the other, which is placed at one side in the athwartship line acts upon the crosshead of the first through a "sway-beam" to the end of which the crosshead is coupled by a short link.

In still another style of engine, the two cylinders are coupled to cranks set at angles of 130° or 150°, thus securing a pretty nearly opposite movement of pistons, and yet allowing the engines to turn their centres easily, without the assistance of a pair of right angles.

The "Palmer Shipbuilding Co.," and, we believe, one or two other firms, are building still another form of engine, see Fig. 7. In their engines, the high pressure cylinder, A, is placed directly above the crank-shaft in the usual manner, but the low pressure cylinder, B, is mounted horizontally and athwartships, and is coupled to the same crank, the piston of one being thus at half-stroke, when that of the other is at the end of the stroke. The pipe connecting the two cylinders and the steam jacket of the large cylinder form together a large reservoir, into which the small cylinder exhausts and from which the large cylinder takes its steam, and excessive irregularity of steam pressure is thus to some extent avoided.

In still another and favorite design, the same action of the steam is obtained with a pair of cylinders side by side, coupled to cranks set 90° apart, instead of by placing the cylinders at angles of 90° with each other.

In this, as well as the preceding style of engine, it is, of course, necessary to provide a small pipe leading steam directly from the boiler to the large cylinder for use when starting. All these forms of engine have been found to give excellent results when well taken care of. The Palmer Co. use the Corliss valve, but not the Corliss cut-off apparatus. All makers steam jacket one, and often both cylinders.

From our own experience and from data gathered from many sources, we should judge that a well built engine of the ordinary single cylinder type, with jet condenser, steam at 30 pounds pressure, and expanding about three times, can be expected usually to work with a consumption of 30 pounds of steam per horse-power per hour, with surface condenser, the same engine should consume less than 25, while the best specimens of the compound engine are reported, with 60 pounds pressure and upward in the boilers, expanding six or eight times, to use 15 pounds of steam or less. Prof. Rankine reports in his "Steam Engines and Prime Movers" that the "Thetis," compound engine consumed but about 10 pounds of steam per horse-power per hour. This was, perhaps, hardly more than an approximation, but the engine was built by Messrs. Rowan & Co., of Glasgow, and steam entered its cylinder with an initial pressure of 108½ pounds per square inch, expanding fifteen times.

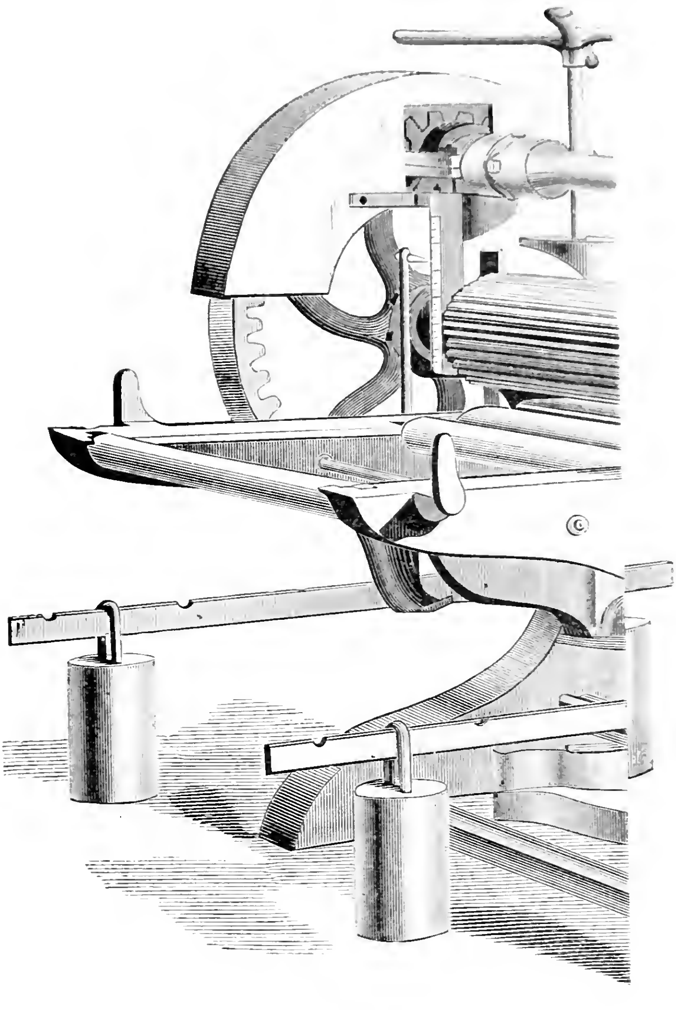
We are prevented by the length to which this paper has already extended from entering into an analysis of the theoretical and practical advantages and disadvantages of the compound engine, and it may more properly form the subject of a separate paper.

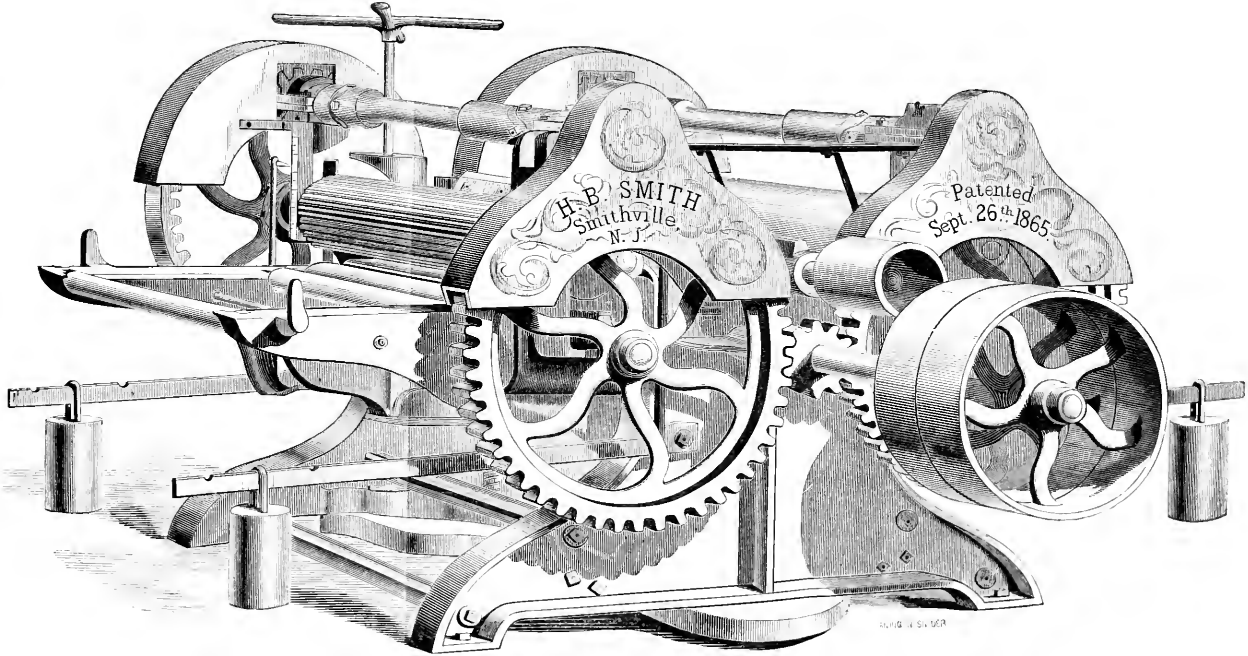
The accompanying table may be of interest in this connection.

Dimensions of Recently Built Steam Vessels.

Engine Builders.	Steamer.	Dimensions of Hull.	Style of Engines.	Size of Cylinders.	I.H.P.	Steam pressure.	Coal. Per I.H.P. per hour.	Speed, knots per hour.	Date.
R. Napier & Co.	"Periere."	339′ × 43½′ × ?	Vertical direct.	2—84″ × 4′	2500	30	3·1 lbs.	14·15	1869
J. Elder & Co.	"San Nanzing." ...	225′ × 32′ × 23¼′	Comp.	2—38″ } 2—76″ } × 4¼′	939	50	2.17	36 5	1870
....	H. B. M. S. Briton....	....	Comp.	57″ } 104¼″ } × 2¾′	2148	58	1·98	......	1870
J. Penn & Co.	H. B. M. S. Hercules.	325′ × 59′ × ?	Trunk.	trunks 48″ 127″ × 4½′	7185	30	2·53	13·39	1869
W. Simons & Co.	"India."	311′ × 36′ × 23½′	Comp.	2—36″ } 2—72″ } × 3′	......	...	36 tons per day.	11·47	1869
Tennant & Co.	"Irene."	252′ × 30′ × 19′	Comp.	31″ } 56″ } × 3′	517	60	2·15	......	1870
A. & J. Inglis.	"Shantung."	215′ × 39′ × 24¾′	Vertical direct.	2—46″ × 3′	890	23	2·01	10·08	1870
Maudsley & Fields...	"König Wilhelm."	365′ × 60′ × ?	Horizontal direct.	3—95″ × 4½′	8664	30	2·56	14·5	1869

U. S. Naval Academy, Annapolis, Md , October, 1870.




H. B. SMITH
Smithville,
N. J.
Patented
Sept. 26th 1865.

WOOD WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from Vol. LX., page 392

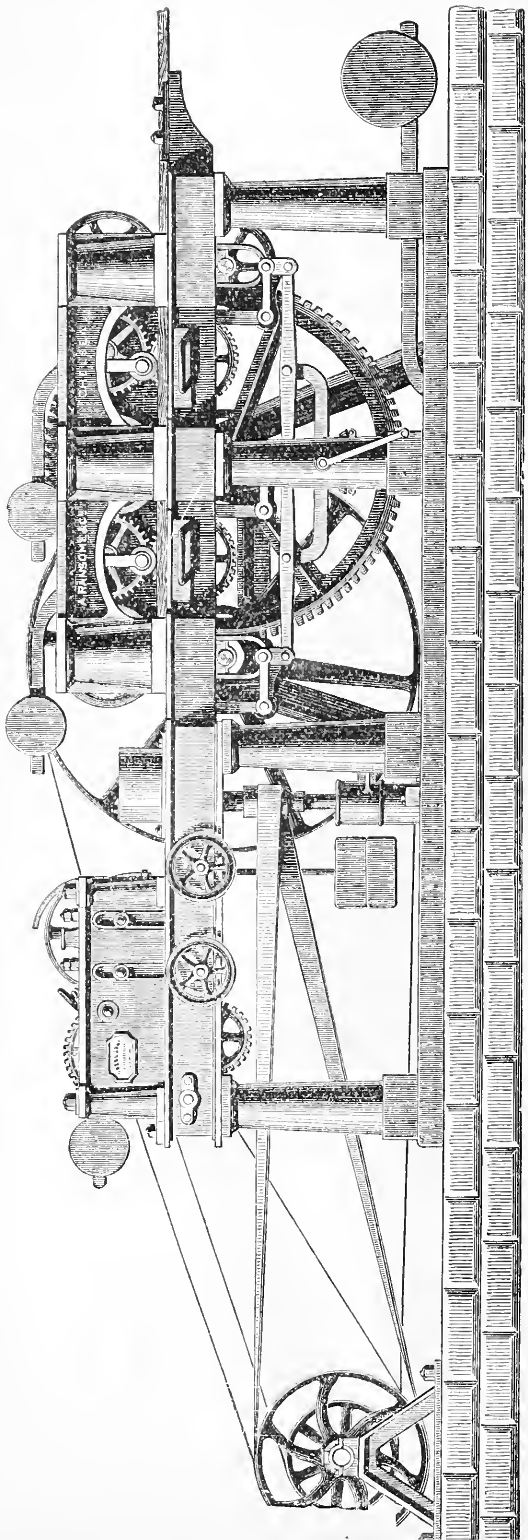
Surfacing Machines.—Surfacer has become the technical name for planing machines that are used to thickness, and dress the surfaces or flat sides of lumber. Machines of this kind were, in the first article on planers, alluded to as "surface gauging planers," and are the popular machines in this country for all kinds of planing that can be done in this manner, and for some planing that perhaps should be done on other machines. The surfacing machine, consisting of a single, or with two cutting cylinders, were called into use mainly by the peculiar nature of the lumber business in this country. The rapidity and cheapness of their work adds but little to the worth of lumber to surface and reduce it to a uniform thickness, in which state it is lighter and cheaper to transport, easier to cut and work, and is ready to receive paint for out-door uses. A first-class surfacing machine, when properly fitted, and strong enough, will dress from two thousand to three thousand feet per hour, of pine boards, on one or both sides, at but a trifling cost—the machine furnishing an excess of fuel over what is needed to drive it, and requiring no skilled care except to dress the cutters.

The feeding mechanism of surfacing machines should consist of three pairs of strongly geared rolls, having an elastic pressure, that can be readily controlled or changed. The bed beneath or opposite to the cylinders should be strong and firm, without any chance of yielding from the action of the cutters. They should be of some hard material, to prevent wear, which is very rapid with "gritty" lumber. Machines with a movable bed, consisting of slats or bars, mounted with links, forming an endless chain, have been introduced in this country for the rougher class of work. The endless table or platen passes over a fixed bed, carrying the lumber under the cutters by the friction on its top surface. The advantages of this arrangement are mainly in the cheaper first cost of the machine, and in obtaining a reliable feed without the expanding gearing that is necessary in the roller-feed arrangement. They are, however, liable to wear out rapidly, from abrasion under the movable bed and the numerous joints and rivets of the chain has deterred most makers from adopting it.

The engraving, Plate V, illustrates a roller-feed surfacing machine, from the designs of the manufacturer, H. B. Smith, of Smithville, N. J. The arrangement of the machine is very clearly shown, and will require no description to be understood by those familiar with this class of machines.

Fig 1 is a side elevation from the designs of Messrs. Allen Ransome & Co., of London, England. The design shows vertical spin-

Fig. 1.

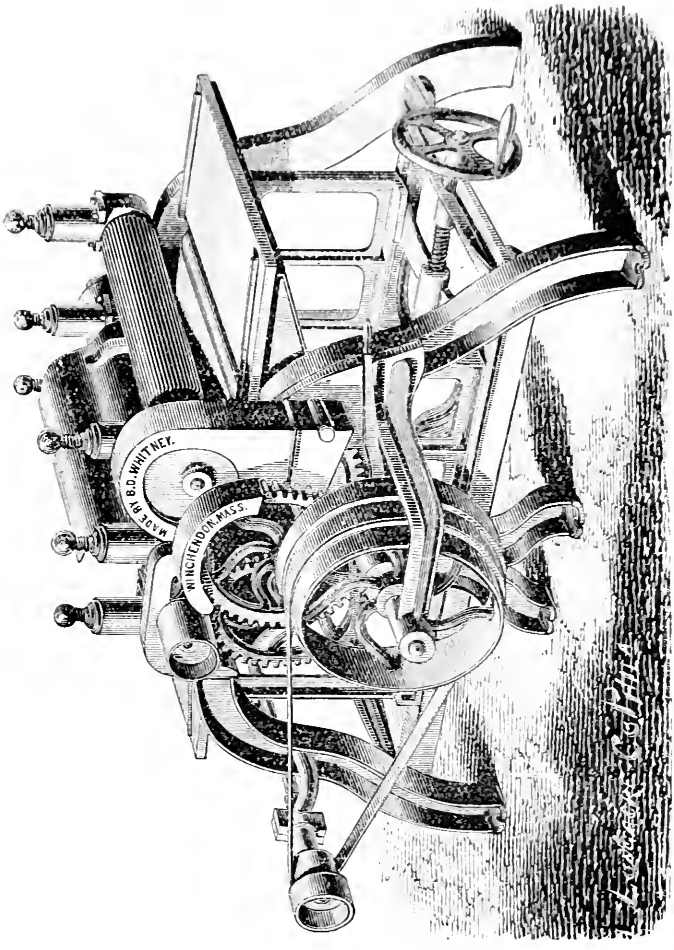


dles for matching, or side dressing, but is adapted to plain surfacing. The lumber is first reduced with rotary cutters, then acted upon by fixed cutters to produce a smooth surface. The application of fixed cutters in wood planing machines with a direct edge, as in the common hand plane, is a subject that deserves a thorough investigation by manufacturers of wood machines in this country. Their extensive use in England and on the continent, unless there is some great difference in the conditions of lumber dressing, would argue their importance for many uses here. The writer hopes, at some future time, to present, through the *Journal*, some views on the matter, and would be obliged by any communication bearing upon the subject.

The machine illustrated is drawn $\frac{1}{2}$-inch to 1 foot, weighs about 5 tons. The medium rate of feed is 45 feet per minute, working from one to three sides of the lumber at a time.

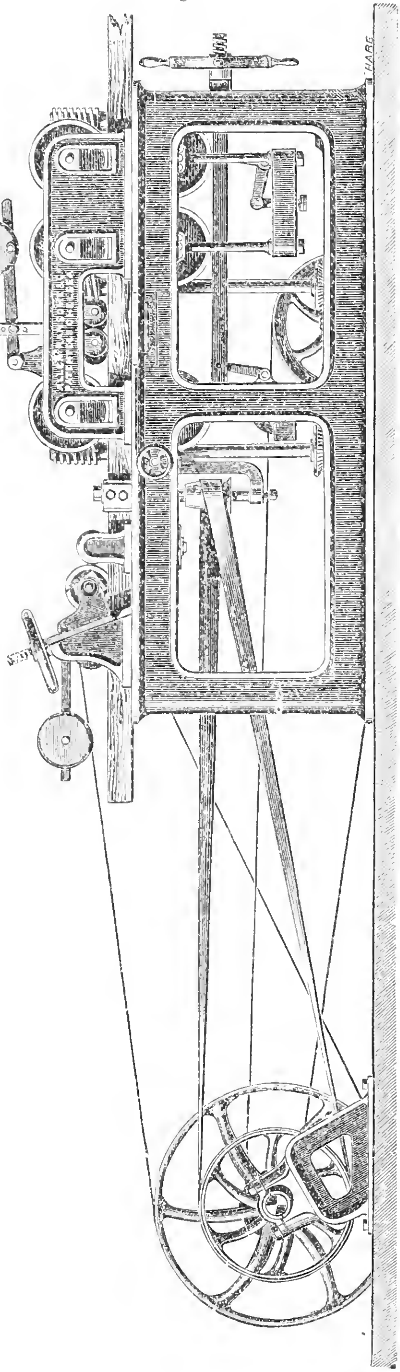
Fig. 2 it a perspective elevation of a surfacing machine from the design of the manufacturer, B. D. Whitney, of Winchendon, Massachusetts. We cannot refrain from calling the attention of our readers to the artistic merit of the engraving by Longacre & Co., of

Fig. 2.



Philadelphia. Although in perspective, the proportions and relations of the parts are clearly defined with an exactness of detail rarely attained in cuts of this kind. This machine has had an extended sale throughout our country, there being at this time more than five

Fig. 3.



hundred in use. It has several peculiar features, which we here notice. The bed is movable, and rests on inclined planes, giving it continually a solid bearing at all points of adjustment. The cylinder and upper feeding rolls are fixed; that is, they have no adjustment for varying dimensions. The lower rolls are geared expansively with the top rolls by a peculiar arrangement of wheels, which could not be illustrated without diagrams. The cylinder is of steel, and, contrary to the popular theory for smooth planing is quite small in diameter. It performance at Paris. at the Exhibition of 1867, excited much comment among English manufacturers who witnessed its work, which was smooth, and almost free from the waves that are usually seen on surfaces planed with rotary cutters.

Fig. 3 is a side elevation of a planing machine from the designs of Allen Ransome & Co., London, having lighter proportions than the one shown in Fig. 1. It is arranged with horizontal and vertical spindles and fixed cutters. The framing, as will be noticed, is cast in one piece, and the whole strongly fitted, and capable of hard service.

MAP OF THE ISTHMUS OF DARIEN.

By John C. Trautwine.

The accompanying map of the Isthmus of Darien is a reduction from one on a large scale, carefully prepared by myself, for my own use. The coast lines are chiefly from British Government charts. The river Atrato is laid down from my own personal survey of that stream, in 1852.

The route surveyed in 1858, by Lieutenant, (now General) N. Michler, U. S. Engineers, for an interoceanic ship canal, has been reduced from the large maps which accompany his Report. It will be perceived that the engraver has inadvertently changed the position of some of the words which indicate the position of this route Thus, the words "ship canal" should have been in a nearly straight line, just above the 7° of latitude. The survey terminated, on the Pacific side, at the little bay of Paracuchichi. It followed the line of the small stream called the river Truandó for several miles. General Michler proposed to unite that stream with the Atrato by a cut shown on the map by a dark, straight line. His summit, near the Pacific, was about 948 feet above mean tide, and at that point he proposes a tunnel, four miles long. Just south of General Michler's route is one proposed for the same purpose by myself some years before, or in 1852. I consider it a matter of regret that it was not surveyed in preference to the other route, inasmuch as the distance is shorter, and the Bay of Cupíca affords (according to Admiral Fitz Roy) an excellent harbor; whereas such is not the case at Paracuchichi. Indeed, with the exception of Cupíca Bay, there is no harbor along that section of the Pacific coast. The Atrato, by my own soundings, affords at least 36 feet of depth, up to Vigia Curbaradór, at which point my suggested line begins. Above Vigìa Curbaradór, which place consists of but two or three huts, the depth of the Atrato diminishes greatly, in consequence of the second channel, called the Caño Tadiá. This caño extends about 30 miles, when it again unites with the parent river, near the mouth of the river Napipí. The Napipí has been much spoken of as a route for a ship canal, chiefly owing to suggestions to that effect by Humboldt. But I found it to be nothing but a small shallow creek, extremely circuitous, and altogether unadapted to that purpose. Moreover, the shallowness of the Atrato from the mouth of the Napipí to Vigía Curbaradór, precludes all idea of

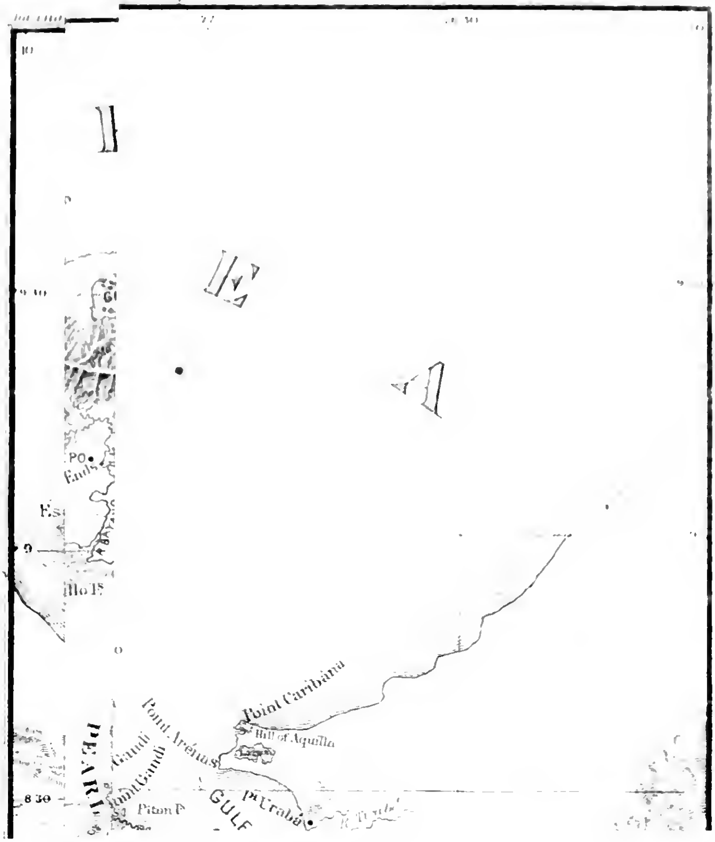
using the Napipí as a canal for large vessels. Extensive marshes, frequently overflowed, border both sides of the Atrato, almost to its very head, and would render the construction of a permanent canal through them an expensive undertaking.

The great bend in the mountains of Espiritu Santo, west and southwest of the gulf of Darien, is given from my own observations, made when ascending the Atrato in 1852. The ridge seen near the Pacific coast, between latitudes 6° and 7¼°, attains a general height of 1000 feet.

The map shows what is known of the country between Caledonia Bay on the Atlantic; and the Gulf of San Miguel, on the Pacific; including the river Chucunaqué, the scene of the sufferings endured by the U.S. Surveying party, under command of the gallant officers, Strain and Truxton. The late efforts of the United States surveying parties, under Commodore Selfridge, have been directed to routes from Caledonia Bay, southwestward, towards the river Savana, which empties into the Gulf of San Miguel. Also, to routes from the Gulf of San Blas, on the Atlantic, southwardly, to the river Chepo, or Bayáno, which enters into the Pacific. The general physical character of the country along all these routes may be inferred from the map. This, however, gives no idea of the difficulties, privations and dangers to be encountered by parties surveying in those wild, inhospitable regions.

A perfectly practical route for an interoceanic railroad can be had by leaving the Atrato at the mouth of Caño Cacarica; thence following along the north side of said caño, to near its head; thence turning southwest, rising along the mountain slopes to where Gen. Michler crossed the ridge, near lat. 7°, long. 77° 36′; and thence descending to Cupica Bay. This route would be about 100 miles long; and the grades need nowhere exceed about 40 feet to a mile, even without a deep cut or tunnel at the summit. With a tunnel two miles long through the ridge at or near Michler's summit, the maximum grade will be reduced to 15 or 20 feet per mile.

Though the engraving does not possess the spirit of the original; still, the map will be of interest at this time, when the attention of the commercial world is being so strongly directed to the subject of an interoceanic ship canal.



Point Caribana
Hill of Aquilla
Point Arénas
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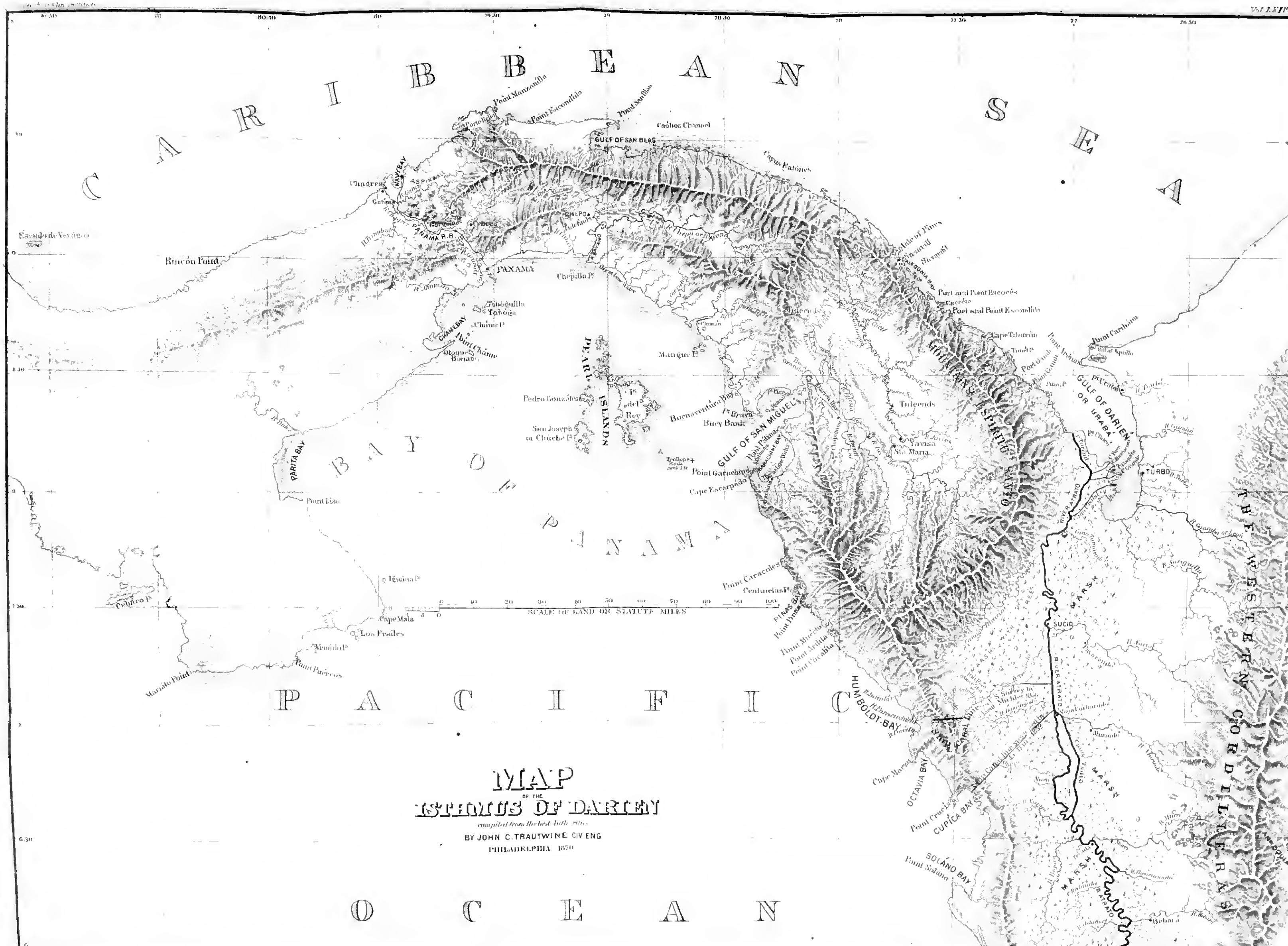
9
8 30



CARIBBEAN SEA
PACIFIC OCEAN
BAY OF PANAMA
MAP OF THE ISTHMUS OF DARIEN
compiled from the best Authorities
BY JOHN C. TRAUTWINE CIV ENG
PHILADELPHIA 1870
SCALE OF LAND OR STATUTE MILES
PANAMA
ASPINWALL
PANAMA R.R.
Chagres
NAVY BAY
Porto Bello
Point Manzanilla
Point Escondida
Point Sasardi
GULF OF SAN BLAS
Caños Channel
Cayos Ratones
Escudo de Veraguas
Rincon Point
Taboguilla
Taboga
Chame I.
CHAME BAY
Point Chame
PEARL ISLANDS
Pedro Gonzales
San Joseph or Chuche I.
I. del Rey
Chepillo I.
Mangue I.
Buenaventura Bay
Buey Bank
GULF OF SAN MIGUEL
Point Garachiné
Cape Escarpado
Point Caracoles
Centuelas I.
PIÑAS BAY
Point Marieto
Point Ardita
Point Cocalita
PARITA BAY
Point Lisa
Iguana I.
Cebaco I.
Cape Mala
Los Frailes
Point Puercos
Mariato Point
HUMBOLDT BAY
OCTAVIA BAY
Cape Marzo
CUPICA BAY
Point Cruces
SOLANO BAY
Point Solano
RIVER ATRATO
MARSH
SUCIO
TURBO
GULF OF DARIEN OR URABA
Point Caribana
Cape Tiburon
Port and Point Escocés
Port and Point Escondido
CALEDONIA BAY
MOUNTAINS ESPIRITU SANTO
THE WESTERN CORDILLERAS
Tuleñas
Yavisa
Sta Maria
Bebara
Bete
78 West from Greenwich

ENGINEERING OF THE PERIOD.

By Wm. M. Henderson, Hydr. Engineer.

(Continued from Vol. LX, page 384.)

We pass on to another remarkable invention, emanating from Harrisburg, Pa.—a simple apparatus for raising water from mines, quarries, &c., particularly recommended, we are informed, for water works. It is composed of two receivers. A single receiving pipe proceeds to the water, branched at its upper end, to the lower end of the receivers, and, continuing upwards, serves as the rising main. These pipes are fitted with suction and discharge valves, similar to a pump; steam is introduced alternately to each receiver. The *modus operandi* is, first, to fill one of these receivers with steam: the communication between it and the steam boiler is then shut off, whereupon the steam condenses, and a partial vacuum created, the atmospheric pressure upon the surface of the water in the well forces a portion up the receiving pipe, and so charges that receiver with water; steam is then re-admitted to the surface of the water and drives the charge up to the point where the water is required to be elevated. The steam connections are so arranged that the operations of charging and discharging are performed alternately, so as to keep the supply as continuous as possible.

The reader will perceive this is, to all intents and purposes, the identical invention of Captain Savery, who obtained a patent for it in the year A. D. 1698. There is no doubt that he received the first idea of this engine from the fire engine described in 1633 by the Marquis of Worcester. Savery's engines, however, were not automatic, but required a laborer to manipulate the cocks. It was reserved for M. de Moura to add a self-acting apparatus for this purpose. Papin introduced a movable disc or float, which was interposed between the water and the steam, to lessen the tremendous loss from condensation which occurred whenever the steam was admitted for expelling the water. This description of engine received the finishing touches from Pontifex, who left nothing further worth improving.

The principal objection to this form of engine, we are told, was found to arise from the great consumption of fuel, a considerable portion of the caloric employed in the generation of the steam being absorbed in heating the new surface of the cold water last raised from the well, and when the water was required to be elevated to

any considerable distance, there was no conceivable mode of obviating this great objection. Savery's engine was not adapted either for the supply of towns or for the draining of mines, two of the patentee's principal objects. His great expectations ended with the erection of a few small engines for raising water in the pleasure grounds of some of his admirers. Savery's engine proving a failure, the mines were only rescued from abandonment by Newcomen, who, as we have stated, shortly afterwards introduced the atmospheric engine. This engine took steam under the piston only, the down stroke being accomplished by the force of the atmosphere, favored by the vacuum produced by the condensation of the steam on the under side.

This was an important step in the history of the steam engine. Already was produced one-half of our steam engine as it exists now The rest was made short work of by the master mind of Watt, who introduced (about one hundred years ago) the feature of condensation in a separate vessel, and afterwards admitted steam to the other half of the stroke, developing the Rotative engine very much as we see it at this day.

Returning to this Harrisburg engine, we have been officially informed that, upon trial, it raised one million pounds of water one foot high by one pound of coal. This is equal to a duty of 112 millions, which, it must be admitted, is good, very good, when we take into consideration that the full amount allowed by the laws which have hitherto governed this universe has been ascertained to be but 47 millions; and this, too, based upon the supposition that the force of the steam could be supplied directly to the water in the receiving pipe, that there shall be no loss by condensation, and a perfect vacuum maintained above the column of water to be lifted without cost. It is somewhat remarkable that the duty should be more than doubled, by the addition of friction, condensation, leakage and the defects incurred from that imperfection, produced wherever machinery is employed. Captain Savery's invention has presented a wide field of action to the professional inventors of our country.

We have his scheme presented to us, in some shape, every year, sometimes with a single receiver, when it is called a *mont jue;* frequently it comes to us with a flexible diaphragm or partition, separating the steam from the water, as suggested by Papin. Under this guise we know it as the bellows pump. It is, however, the

same old thing; there is no honest chance of ever making any money out of it. That there is a field open to those who, from prescience or ignorance, cannot be classed as strictly honest, there is no denying.

We have before us a pamphlet purporting to be a system of fire protection and water supply for cities and villages, advocating *Rotary pumps.* We are informed they employ orators to discourse to the multitude the great advantages to be obtained from the simple *Rotary* principle. No reservoirs or fire engines with this system are at all necessary, said system consisting principally in employing a number of rotary and single-acting plunger pumps instead of one or two double-acting forcing pumps of corresponding aggregate power. Were it desirable to subdivide the work, for any pretended purpose, surely such necessity could not have escaped the attention of pump builders generally. The system so lauded is not even new. We know situations where the same duty has been performed in a quiet way for years, it being at best but a way of doing things by halves, without any regard to that economy of working so important where the saving of fuel is a desideratum. The pamphlet is full of notices taken from country papers, written, it is presumed, by interested parties, in the most flagrant violation of all our preconceived knowledge of such ruinous things as *Rotary* pumps, high-velocity, impracticability of carrying out either the condensing or expansive principle of steam—a source of economy not to be lost sight of where anything beyond first cost or bribery for adoption is concerned. As an advertising medium to our rural friends, the wonders performed by this astonishing *system* exclude the hope of further improvement. We are gravely informed that streams turned upon the ground plowed the earth into deep ruts; heavy barrels encountered by the same, like shuttle-cocks, were carried instantly a hundred feet into the air. Even an unfortunate ex-Mayor, who unluckily placed himself under one of the streams, was raised bodily off his feet, and suspended, like Mahomet's coffin, in the air, or, like the marble that dances over a common fountain, was compelled to perform a ludicrous ride upon the seething torrent, and subsequently dashed at a distance sprawling upon the ground. If there were no other objections to this system, we think the peril in which it places human life is sufficient to make us pause before we invite such a devastating power in our midst, unless, indeed, we employ the energies of the engine against the burning edifice, and level it summarily to the ground—a matter (there is no doubt, whatever, from the description of it,) quite within the scope of this engine's capabilities.

Philadelphia Hydraulic Works, Oct. 7, 1870.

Mechanics, Physics, and Chemistry.

TWO NOTES ON THE DISPERSION OF LIGHT.

By M. Th. Ricour.

(From the Comptes Rendus of the French Academy for December 13, 1869, and January 17, 1870.* Translated by Prof. C. A. Young, Ph. D.)

Experiment has demonstrated that the vibrations of sound are transmitted through air with a velocity independent of its pitch; luminous vibrations are also propagated in free ether with a velocity independent of their wave length. A red ray and a violet emitted at the same instant by a star reach the eye of the observer at the same instant, however great the distance traveled. It is no longer so when light penetrates transparent bodies. The rays of different wave length are then transmitted with velocities decreasing from the red to the violet, and we designate by the name of *dispersion*, this property of transparent bodies which is specific for each substance.

It is owing to this dispersion that a beam of white light is spread out into a spectrum in passing through a prism.

The note which we have the honor to present to the Academy aims to exhibit both the cause of dispersion and the very simple law which governs it.

In the first part of the memoir we establish by considerations in some degree elementary an equation of oscillatory movement for a plane polarized wave, taking account of the fact that all bodies are composed of molecules placed at finite distances from each other, we assume that in a crystallized body all these molecules are of the same magnitude, and regularly distributed in such manner that between two parallel equidistant planes there is always the same number of molecular systems, (*i. e.*, the crystal may be divided into strata by a series of parallel planes at certain equal small distances in such a way that the constitution of any one stratum shall be identical with that of any other.—*Trans.*)

* The memoir of which these notes give an abstract was referred to a committee composed of MM. Bertrand, Serret and Fizeau. Their report upon it has not yet appeared, nor the third note which he promises in the conclusion of the second. Of course it is impossible to judge from his abstract whether his memoir really makes out all he claims, and I should like much to see the report of the Committee before endorsing his conclusion.

Developing into a series this equation of oscillatory movement, we can obtain the formula of Cauchy by a first approximation limited to the two first terms of the development.

Instead, however, of proceeding in this manner by approximation, we determine directly the general term of the complete integral and obtain a rigorous expression for the velocity of propagation of a wave of given length. The problem of the dispersion is thus solved for homoedric crystals.

The formula we obtain is the following: sin. $\frac{R a \pi}{l} \quad \frac{\rho a \pi}{l}$: in which R is the particular index of refraction which corresponds to the wave length l, and a and ρ are constants whose physical signification is perfectly determined; a is the minimum distance between two planes, parallel to the plane of the wave, and dividing the medium into strata of identical molecular constitution, while ρ is the limiting index of refraction for waves of great length, the relative position (orientation) of the plane of vibration, and the wave front being constant, ρ varies with this relative position according to known laws.

In a second part of the memoir we compare this formula with the results of experiment. Detailed tables are given for quartz and Iceland spar, whose indices of refraction have been determined by M. Mascart through the whole extent of the spectrum from the extreme red to the extra-violet. The differences between calculation and experiment (perhaps about $\frac{1}{5000}$ of the value of the computed indices of refraction) do not exceed, for the series observed by M. Mascart, the differences which exist between the results found for a given ray with different prisms of quartz by such observers as Rüdbey, Esselbach and Fizeau.

Finally, as the formula of dispersion is based upon the hypothesis of a perfect equality of the molecules, and a distribution perfectly regular, and as experiment indicates that this formula applies with great accuracy to bodies not crystallized but homogeneous, like the flint and crown glass of optical instruments, we calculate for these substances, as well as for quartz and Iceland spar, the minimum distance a between two parallel planes dividing the vibrating medium into layers of the same molecular constitution.

We thus find that this distance a expressed in ten millionths of a millimetre is equal—

For the extraordinary ray of quartz to	. .	252·33
*" " ordinary " "	. .	252·33 (sic.)
" " " " Iceland spar	. .	300·59
" " extraordinary " " "	. .	240·48
" a prism of flint glass by Steinheil	. .	347·51

It is known that the wave length for the ray D is 5888·0 (in the same units.) We can thus form a clear idea of this distance α, which is closely connected with the distance between the molecules, and we see that for the substances enumerated, it is from 17 to 25 times less than the wave length of the ray D.

The absolute distance between the atoms of the ether is a very minute fraction of the distance between the ponderable molecules, and there should therefore exist in the free ether, waves much shorter than the distance α calculated for the different bodies (above named). A new law of refraction determines the transmission of these very short waves through the layers whose thickness is α, which act as true media, periodically uniform, with an index of refraction lower than that of the substance considered in mass.

These invisible waves, extremely short, form a separate spectrum which is partially superposed upon the luminous spectrum in the neighborhood of the ray A, but extends far below the extreme red where its presence is indicated by thermoscopic apparatus.

We thus establish a characteristic difference between the luminous vibrations of long period in the ultra red portions of the spectrum and the calorific vibrations whose presence in the same region is incontestable.

The formula for the dispersion gives the exact limit below A for the termination of the spectrum formed by vibrations of long period.

Below this limit every luminous vibration is necessarily excluded, but we still find extremely rapid vibrations, whose living force is considerable, and which constitute, so to speak, *pure* heat in opposition to *luminous* heat.

Portion of Second Note.

Direct experiment has proved that the wave lengths go on diminishing from A towards the extremity of the ultra violet spectrum. It has been inferred that the same law holds below A; that is to say, that the wave lengths continually increase towards the termination of the calorific spectrum. But this conclusion is unwar-

* This appears to be a mistake either of the press or pen —*Trans.*

ranted; it is a simple hypothesis not based on any direct experiment.

On the contrary, it is in opposition to the theory of dispersion, as I propose to demonstrate in the note which I now submit to the judgment of the academy, substituting for this hypothesis the indications of the theory.

The theory indicates the existence of two independent spectra, governed by distinct laws of dispersion.

The first spectrum belongs, in quartz, to waves of a length varying from $l = \infty$ to $l_0 = 1215$ (ten millionths of a millimetre.)

The law of dispersion for this spectrum is given by the formula $\sin. \frac{R\, a\, \pi}{l} = \frac{\rho\, a\, \pi}{l} = \frac{l_0}{l}$, and the values of R (the index of refraction for wave length l) are comprised between $R = \rho$ and $R = \rho \frac{\pi}{2}$.

The second spectrum is made of waves whose length lies between $l = 0$ and $l = 1215$, but for the most part extremely short as compared with the wave lengths of the rays in the first spectrum, and consequently much nearer $l = 0$ than $l = 1215$, this second spectrum forms by itself alone the band of slightly refracted rays, which is made manifest by thermoscopic apparatus below the limit of the luminous spectrum, and prolongs itself above this limit so as partially to cover the extreme red of the first spectrum, yet without retaining any appreciable intensity beyond the neighborhood of D.

The distinction which theory indicates between the two spectra makes it easy to understand how certain bodies are opaque, and at the same time diathermanous, while others allow the light to pass and stop the calorific vibrations. The bodies are in the presence of two orders of vibrations. One set impresses its oscillations upon the periodically homogeneous layers and causes them to move *en masse;* the other set operates upon the component atoms of the layers. There is a certain amount of independence between these two modes of vibration which explains the passage of the one and the absorption of the other.

We owe to M. Mascart an observation extremely interesting and confirmatory of the theory. In a spectrum produced by a prism of quartz, a trained eye can distinguish in the ultra-violet region, a band six or seven times as long as the ordinary luminous spectrum (from A to H). This band forms a prolongation of the spectrum,

gradually fading out towards the upper end in a continuous manner, and it is longer as the eye is more sensitive.

On the contrary, below the ray A, where the vibrations over a length equal to that of the luminous spectrum possess a living force incomparably greater than in the ultra-violet region, the most sensitive eye can only perceive a very narrow band of dull red light. This narrow band which affects the eye, is the zone in which the wave lengths increase continuously from $l=7604$ for the ray A to $l=\infty$; it has, in fact, as it ought, according to our theory, a length which is less than one-third of the length of the luminous spectrum. At the limiting point there is an abrupt termination of the spectrum formed by the longer waves, and the sense of vision is completely insensible to the vibrations of short period which exist in that region.

Summing up, then, in our first note, we have given the theoretical law of dispersion in homœdric crystals perfectly homogeneous, and have shown that the law is verified by experiment. In the present note we have established that the spectrum embraces two orders of vibration governed by different laws of dispersion.

The vibrations of long period are propagated by means of the oscillatory movement of the periodically homogeneous layers into which the medium resolves itself under the action of the ponderable molecules; these layers, limited by *surfaces of minimum elasticity*, possess a certain thickness α, which forms, as it were, the constant of dispersion for that medium.

The short period vibrations are propagated across these layers (of thickness α) in the interior of which the mean elasticity is greater than that which operates in the propagation of the longer waves.

We have established that the free ether is, in effect, able to transmit waves incomparably shorter than those of light, and we have indicated incidentally in what manner the observation of the lines in the spectra of variable stars may lead to a determination of their distance from the earth.

We have also made it appear that all known experiments confirm the theoretical views that have been set forth, and have indicated new experiments to be executed, in order to determine the lengths of the calorific waves as actually as the lengths of the luminous waves have already been measured.

It remains for us to make known the origin of these two orders

of vibrations which are propagated in the ether, and the conditions under which each attains the maximum of intensity.

It is, in fact, a general law, that all bodies, solid or liquid, emit at a high temperature vibrations of two periods extremely different, which correspond, the first order, to the maximum of intensity in the visible spectrum, the second, to the maximum of intensity of the invisible spectrum, while the vibrations of intermediate duration are, so to speak, absent, or at least possess a living force quite inappreciable.

The free ether, as we conceive, does not offer in itself, any explanation of this general law, for it can propagate with the same facility vibrations of every wave length. It is to the source of the vibrations that we must ascend; and the molecular constitution of bodies put us on the track of a rational explanation of the existence of two maxima around which, so to speak, group and condense themselves, the vibrations of the visible spectrum, and those of the invisible.

Every body is made up of *physical* molecules; every physical molecule is an assemblage of *chemical* molecules; two orders of vibrations, of widely different periods, correspond to these two orders of molecules; these molecular vibrations communicating a portion of their living force to the ether give birth to two orders of undulatory movement, constituting the radiance of light and heat. The slower luminous vibrations emanate from the *physical* molecules; the more rapid thermal, from the *chemical* molecules or atoms.

The formula which answers to these vibrations explains, at the same time, both the fusion of bodies and the dispersion of light. The developments into which it will be necessary to enter will form the subject of a third note. (This third note has not yet appeared.—*Trans.*)

Furnace Slag is utilized in Belgium by allowing it to run off into moulds along the sides of the furnace, in which it assumes the form of rectangular blocks of any size. When cold, the mass forms a compact, homogeneous slag, very much resembling porphyry, and equal, for building and engineering purposes, to the best natural stone that can be procured from the quarry.

ON THE REDUCTION OF LIGHT DUE TO THE PRESENCE OF CARBONIC ACID IN ILLUMINATING GAS.

(Read before the American Association for the Advancement of Science, Troy Meeting.)

By FRED. E. STIMPSON.

[THE experiments here detailed were made by Prof. William B. Rogers, in 1863, and a meagre abstract appears in the Reports of the British Association, at its Bath meeting, 1864, p. 40. The details have never before been published.—F. E. S.]

It is a familiar fact that carbonic acid gas is incapable of burning, and that a flame of any kind plunged in an atmosphere containing a large amount of it, is immediately extinguished. Its presence, therefore, in considerable quantity, in ordinary illuminating gas, might be expected to impair its illuminating power. But in the small proportion of one or two per cent., in which, at some manufactories, it is allowed to remain in the gas, the evil is so inconspicuous as to have led to the belief that a more complete removal of the impurity is practically of no importance.

The opinion has even been advanced, that in such small quantities, its action is merely that of diluent, serving, when present in such gas, to facilitate the combustion, to the extent, at least, of compensating for the loss of light it might otherwise occasion.

These reasons in favor of an incomplete removal of the carbonic acid are moreover strengthened by the fact, that in separating the last portions of this impurity by the dry lime, or other purifying process, we at the same time arrest a small portion of the illuminating ingredients of the gas, and thus run the risk of weakening, instead of strengthening its illuminating power.

These vague and uncertain impressions as to the action of small quantities of carbonic acid, and as to the economy of its removal, suggest the importance of a thorough experimental investigation on the subject, and have led me to make the series of observations which follow; offering, I believe, the first conclusive results thus far published on this interesting question in the science and economy of gas lighting.

Mode of conducting the experiments.—1. The carbonic acid was evolved from Bi. Carb. Ammonia, by the action of dilute sulphuric acid, using the common form of self-regulating apparatus, and passing the gas through water in a wash bottle properly connected with the exit pipe.

2. The mixture of carbonic acid and gas was made in a diaphragm gas-holder, from which it was afterward delivered to the burner in the photometric experiments. To effect this mixture, gas was turned on to one side of the diaphragm, and the other compartment, as far as possible, emptied. The carbonic acid was then turned in upon the latter until a sufficient volume was introduced, then this compartment was filled with gas, the first gas admitted being expelled in corresponding quantity from the other side. The whole being closed in, the vessel was repeatedly inverted and turned from side to side, with the view of thoroughly incorporating the contents, and when this was thought to be effected, and before connecting the holder with the photometrical apparatus, a portion of the mixture was taken out for analysis.

3. The percentage of carbonic acid in the mixture was determined in a graduated tube over mercury. In the first experiment the tube was filled by displacement through mercury. Afterwards it was found more convenient, and quite as accurate, to fill by displacement with a long inserted tube in air.

The absorbent was a ball or rod of caustic potassa (the latter being the more prompt), fixed upon the end of a long wire.

4. The illuminating power was determined by passing successively the common gas and the mixture through the same dry meter, at equal or nearly equal rates (5 feet per hour), and burning them from the same 15-hole argand burner, and comparing their respective lights with a third light, also burning 5 feet per hour, at the other end of a photometric bar, 150 in. long.

These two results were then reduced to equality of delivery.

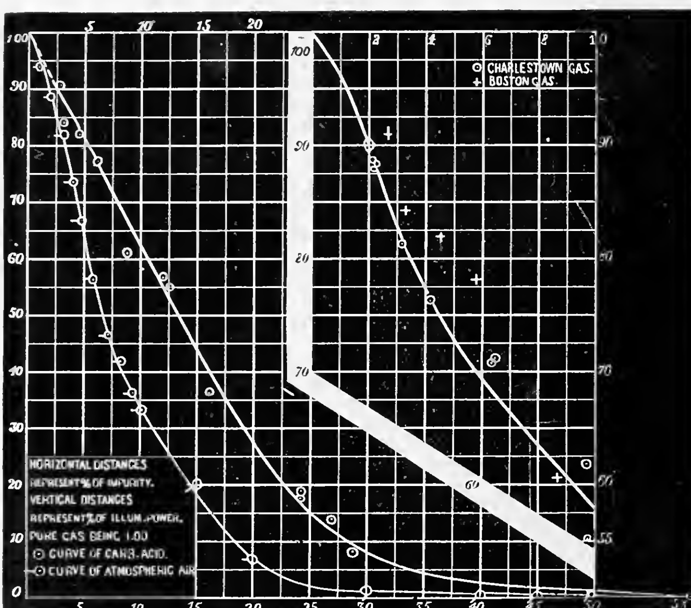
EXPERIMENTS.

	CO_2	Ill. Power.
(1.) Boston Gas, containing about	2·6 p. c.	1·000
Mixture " by determination	24·	·203
" " "	26·6	·152
" " "	16·25	·400
" " "	8·75	·667
(2.) Boston Gas, " "	2·5	1·000
Mixture " "	12·5	·609
" " "	29·	·084
" " "	58·5	·000
(3.) Boston Gas, " "	2·50	1·000
Mixture " "	24·	·193
" " "	12·	·619
(4.) Boston Gas, " "	2·8	1·000
Mixture " "	4 6	·903
" " "	4·4	·936
(5.) Boston Gas, " "	2·4	1·000
Mixture " "	3·3 ?	·921
" " "	5·8	·854

NOTE.—From the above we obtain the following table: Allowing 2 6 per cent. = to produce a loss of 2·6 × ·0364 = 094 loss of light.

Per cent. CO_2. Pure Gas 0.	Ill. Power = 1·00.	Loss.	Per cent. loss Ill. Pow. for each per cent. CO_2.
2·6 =	·906	·094	...
3·3 ? (4·3)	·840	·160	5
5·8	·779	·221	4
4·5	·820	·180	2
8·75	·604	·396	$4\frac{1}{2}$
12·	·563	·437	$3\frac{1}{2}$
12·5	·554	·446	$3\frac{1}{2}$
16·25	·363	·637	$3\frac{3}{4}$
24·	·183	·817	$3\frac{1}{2}$
24·	·175	·825	$3\frac{1}{2}$
26·61	·137	·863	$3\frac{1}{4}$
29·	·076	·924	$3\frac{1}{8}$
58·5	·000	1·000	...

I have put these results in the form of a curve, and, for the purpose of comparison, have added a curve representing the loss due



to the addition of atmospheric air, taken from Audoin and Bérard's Experiments. *Annales de Chemie*, &c., 1862.—F. E. S.

In the next experiments the gas was passed through hydrated lime, according to the ordinary method of the dry lime process.

(6.) Boston Gas, Carbonic Acid (undetermined)		1·060
The same purified through Lime, "		1·060
(7.) Boston Gas, Carbonic Acid, 2·2 per cent		1·[illegible]0
The same partially Purified, ...		1·050

The difference between experiment 6 and 7 may have been partly due to the presence of a larger amount of carbonic acid in the former case. This small effect on the illuminating power of the 2 per cent. of carbonic acid taken out is in striking contrast with that observed in the former case, where 2 per cent. was added, and leads to the suspicion that the lime removes some of the illuminating ingredients at the same time that it abstracts carbonic acid.*

(8.) The lime was removed and replaced by broken fragments of pumice-stone, boiled down in solution of potassa (13°) until the water was nearly all evaporated.

	Partially purified gas, carbonic acid		0·3	per cent.	1·070
	Boston Gas,	" "	2·7	"	1·060
	" " purified	" "	0	"	1·055
(9.)	" "	" "	2·7		1·000
	" " purified	" "	0·5		1·073
(10.)	Boston Gas		2·58		1·000
	Purified so that it did not act on baryta water while passing through for 5 minutes		0·		1·061
	The same partially purified		1·61		1·035

These results not being altogether satisfactory, further experiments were made upon gas manufactured by the Charlestown Gas Light Company, in the office adjoining their works.

This gas was purified by the dry lime process, and being nearly free from carbonic acid, was well suited for determining the effect of small additions of this impurity on the illuminating power. Observations with the absorption-tube, made at intervals during

* Indeed, both in these and next two experiments with potassa, the purifying material was colored slightly green by the absorption of some other ingredient than carbonic acid.

It was found, also, that the lime and potassa soon ceased to act upon the acid, and, on opening the purifier, this loss of action was accounted for by finding the purifying material quite *dry*. It action could be restored again, for a time, by remoistening it. That this inaction does not occur so soon when the crude and sulphurous gas is acted upon in the ordinary dry lime process, I think, is quite clear, for I have frequently determined the carbonic acid in gas purified by that process, and have found, almost without exception, that when the sulphuretted hydrogen was taken out, I could discover but faint traces of carbonic acid. And it has been equally true, that when sulphuretted hydrogen was present, carbonic acid was also present.—F. E. S.

the continuance of the experiments, gave the percentage of carbonic acid in the gas 0·3, 0·3, 0·2, 0·2.

The following table gives the results obtained by these experiments: pure gas being 1·000.

Per cent. Carb. Acid in gas.	Ill. Power.	Loss of Ill. Power.	Loss per cent. Ill. for per cent. CO_2.
1·0	1·000		
1·9	·900	.100	5·2
2·1	·888	·116	5·5
2·2	·878	·122	5·5
3·1	·814	·186	6·
4·2	·769	·231	5·5
6·6	·707	·293	4·4
6·7	·710	·290	4·3
9·7	·555	·444	4·5
9·7	·618	·318	3·9

From these results, it would seem that at least 10 per cent. of the light was destroyed by the addition of 2 per cent. of carbonic acid; and it is but reasonable to expect that if we could take out that 2 per cent. without removing any illuminating ingredient, there would be a corresponding gain.

LIST OF OBSERVATIONS ON THE POLARIZATION OF THE CORONA.

By Prof. Edward C. Pickering.

In the observations of the eclipse, on the 22d December of last year, one of the principal questions to be determined will be the constitution of the corona. As both the spectroscope and polariscope will be used for this purpose, and it seems desirable to collect what has already been done with these instruments. The observations with the spectroscope are well known, being confined to the eclipses of 1868 and 1869. In the former, nothing unusual was seen in the corona spectrum, and it was supposed to be the same as that of the sun. The observations of last year, however, especially those of Prof. Young, showed no dark lines, but at least one bright one. The observations with the polariscope are more scattered, but the following list includes the most important. I have endeavored to give, where possible, the exact words (or the most literal translation) of each observer's report, with the place of its publication, and in some cases a short criticism.

This question appears to have been first suggested by Arago in

1842. He says: "It is not probable that the light of the luminous lunar corona can show traces of polarization. It would still be well to determine the fact by the aid of a polariscope."—*Comptes Rendus, XV*, 1842, *p.* 855.

ECLIPSE OF 1842.

Arago at Perpignan.—"I instantly seized a polariscope *à lunules*, that was beside me; I handed over to M. Victor Mauvais a colored banded polariscope, and began to explore with my instrument the environs of the luminous aureole, the aureole itself, and even the atmospheric region which was projected on the lunar disk. Everywhere I saw the two *lunules* tinted with the complementary colors which indicate, infallibly, the presence of polarized light in every ray subjected to the delicate analysis of the instrument." As he was unable to determine the intensity of the polarization, or to tell whether that of the corona was more marked than that of the adjacent sky, he concludes: "I have no means of judging, from my observations, whether the light of the corona is polarized or not."—*Arago's Astron. Populair, III*, 642.

Mauvais at Perpignan.—"During the total eclipse I directed a polariscope called Savart's to the moon and the ring, and I saw iridescent bands. The maximum of intensity corresponded with the horizontal position of the bands. They were very bright on the ring, and beyond; they appeared less distinct on the moon itself, yet were distinctly visible even there."—*Arago's Astron.*, III, 642.

The brightness of the lines must have been at a maximum when vertical as well as when horizontal, since the intensity in positions at right angles is always equal. Apparently each image observed by Arago was of uniform color throughout, and therefore its plane of polarization everywhere the same, and the observation of Mauvais shows that this plane was not inclined, but either horizontal or vertical.

ECLIPSE OF 1851.

Abbadie at Fredericksweerk.—"I had inserted a plate of quartz between the object-glass and eyepiece of my telescope, and applying a double refracting prism to the eyepiece as an analyzer, I perceived that the light of the ring was strongly polarized. I could not distinguish any trace of color on the dark disk of the moon, but the clouds may have been less transparent in that part."—*Arago's Astron.*, III, 610.

Dunkin at Christiania.—"Troubled by clouds. Little appearance of the corona was seen, and not a trace of polarization; green was as bright as any other color."—*Astron. Month. Notices, XII*, 45.

The last statement, which seems to have puzzled the writers of the time, was probably made to refute an earlier observation, to the effect that green was absent in the light of the corona, and has no relation to the test for polarization. See accompanying letter.

Carrington at Lilla-Ider used a Nicols prism. "I tried this means for an instant on the ring, but without success." His instrument was in good order, since, when directed to the atmosphere at a suitable distance from the sun, it indicated the existence of polarized rays.—*Arago's Astron., III*, 610.

Eclipse of 1858.

Liais at Paranagua.—Instruments used, a tourmaline plate and Savart's polariscope, "which, many have assured me, renders most distinct the existence of polarized rays, and the direction of their plane, which is normal to the limb. The double refracting prism of small angle has enabled me to recognize that the protuberances gave two equal images in spite of the polarization of the base on which they were projected, because the slight separation of the two images rendered this polarization equal for both." The neutral point in the atmosphere, he states, was in the region of the sun; hence, no confusion was possible. "Moreover, if I have found the polarization of the corona feeble, compared with the ordinary atmospheric polarization, I no less declare that it is undoubtedly much greater than other polarizations well known, such as that of the surface of the moon. It was even perceptible by a small Savart's polariscope, which did not allow us to see the bands on the moon in the conditions of the maximum polarization of this body."—*Comptes Rendus, LI, p.* 769.

As the atmospheric polarization is caused by the sun, the neutral points are always at a constant distance from this body, and it is difficult to understand how the sun could then coincide with them, rather than at any other time.

Eclipse of 1860.

Abbadie at Briviesca.—Used double image prism and plate of quartz, giving contiguous imagas. He found the light of the protuberances unpolarized.—*Comptes Rendus, LI, p.* 705.

Secchi on the summit of Mt. Michel.—"I then placed my eye to an Arago's polariscope, already directed very near the sun, and I perceived that the two images were not of equal color, and that the corona in one was elongated in one direction, and in the other in a direction perpendicular to the first; but I could only give a few seconds to this examination."—*Comptes Rendus, LI. p.* 158.

It seems as if the elongation observed must have been imaginary, since the plate of quartz or selinite in the polariscope would have prevented this effect, while if they had been removed by accident, no difference of color would have been perceptible. We could only account for either effect separately, but not for their simultaneous appearance.

Prazmowski at Briviesca.—Used a telescope, with terrestrial eye piece, magnifying 22 diameters. At common focus of object-glass and eye-piece, a quartz plate of double rotation was placed, its thickness being such as to give the sensitive tint. A Nicols prism was interposed between the first and second lens, where the bundle of rays was most narrowed. The distinctness of the image was not thus affected. The field was divided into two parts by a black line, and the prism and plate turning together, there was absence of color only when this line coincided with the plane of polarization. The image of the sun was brought into the centre of the field, the line of junction being vertical, and cutting the disk into two equal parts. Two segments of the corona were seen not equally colored throughout. The upper and lower extremities of each segment in contact with the line of junction of the quartz were always uniformly colored; to the right and left of these extremities the two halves were strongly colored of complementary tints, one red, the other green.

A motion of rotation imparted to the eyepiece around its axis did not change the colors with regard to the line of separation of the quartz. The light of the corona was then polarized, and its plane of polarization coincided with the normal to the contour of the moon.

This was not a mere trace of polarization, but most intense colors: on one side a most brilliant ruby (*le rubis le plus vif*), and on the other, the perfect emerald green (*l'emerande la plus pure*). As well as I remember, the part of the corona most strongly colored did not correspond with the most luminous portion, but is found at a certain distance from the circumference of the moon.

A second telescope, of twice the power of the first, was used for the protuberances. Between the first and second lens of the eyepiece was placed a plate of quartz, perpendicular to the axis (*perpendiculair à simple rotation*), giving a red tint. In front of the eyepiece, a double refracting prism of small angle was placed, separating the images 1½′. The protuberances were thus separated, but the corona images overlapped, giving a white background. By this means it was found that the light of the protuberances was unpolarized.—*Comptes Rendus, LI, p.* 195.

These observations seem to have been made with great care, and are among the first that are recorded with sufficient detail to permit of a careful criticism. Unfortuately, two errors occur in the fundamental statement that the two halves of the field are colorless when the line of junction is parallel to the plane of polarization. In reality they are never colorless, but in this position are of the same color, and, what is more important, they are again, of a uniform tint when the line of junction is perpendicular to the plane of polarization. This is obvious from the theory, and is verified by experiment. Let us now see what would have been the appearance, if the corona had been strongly polarized in planes passing through the sun's centre. The upper and lower, or N. and S. parts, would have been of uniform color on each side of the line of junction, since their plane of polarization would have been parallel to it. The E. and W. parts would also have been alike, since their plane is perpendicular to the line of junction. The most marked colors, however, would have been at angles of 45°, the N. E. and S. W. being alike, and complementary to the N. W. and S. E., one being red, the other green. These appearances would be so striking, and so utterly unlike those actually observed, that there seems no chance of their being mistaken.

Eclipse of 1868.

Campbell at Jamkandi.—Used a 3-inch telescope, with three eyepieces, giving powers of 27, 41 and 98, two analyzers, a double image prism and a Savart's polariscope. First, with a power of 27 and a field 45′ diameter. "A most decided difference was at once apparent between the two images of the corona." He then applied the Savart's polariscope, which gave bands at right angles to the limb, distinct but not bright, and with little if any appearance of color. On turning the polariscope in its cell, the bands, instead of appearing to revolve on their own centre, passing through the va-

rious phases of brightness, arrangement, &c., [illegible] the limb, always at right angles thereto, and [illegible] change in intensity or any at all in arrangement.

The point at which they seemed strongest was about 110° from the vertex, and I recorded them as "black centred." [illegible] eye piece, giving power of 11, and the [illegible] bands much brighter than before, colored, and [illegible] tangential to the limb, at a point about 280° from the vertex.—*Proc. Roy. Soc.*, 1868, *November* 19, *p.* 122.

Winter at Masulipatam.—He used a telescope of Cooke and Sons, of $2\frac{1}{2}''$ aperture and $28''$ focal length, with a Savart's polariscope, and double image prism and quartz plate cut perpendicular to the axis. On examining the light from the corona, by means of the Savart's polariscope, he found it very strongly polarized every where in planes radial to the sun's centre. The bands were extremely vivid near moon's limb, and faded off with the corona. Several portions of the corona were successively tried, and in all the white central bands were brightest where they were radial to the sun, and the black central bands were equally marked when they were tangential to the limb.—*Phil. Mag.*, *Jan.*, 1870, *p.* 17.

ECLIPSE OF 1869.

Smith at Eden Ridge.—In a note to the writer, Prof. Smith, states that a member of his party found, that with "an Arago polariscope, decidedly *no traces of polarized light could be detected* in the light of the corona."—*Dec.* 20*th*, 1869.

Pickering at Mt. Pleasant,—The writer used an Arago's polariscope, and observed that "the two images were precisely alike and both pure white, but one was on a blue, and the other on a yellow background. From this we infer that the corona was unpolarized- or at least that the polarization was too slight to be perceptible." The colored background was accounted for by light reflected by the sky from the earth beyond the limits of the shadow."—*Jour. Frank. Inst.*, *Oct.*, 1869, *p.* 285; *Dec.*, 1869, *p.* 372.

It is difficult to account for the great variation in these results. Moigno suggests that it may be due to real variations in the corona, but this seems scarcely probable. The polarization of the sky may have some influence, and if this is due to the light reflected from the earth beyond the limits of the shadow, would depend on the sun's altitude, and whether the illuminated surface were land

or water The polarization may be very slight, and hence not perceptible with some of the instruments. A series of experiments are now being conducted in the Physical Laboratory of this Institute by Mr. W. O. Ross, to compare the delicacy of different polariscopes, and to show how small a proportion of polarized light each will show. It seems scarcely possible, however, that the marked polarization described by Prazmowski and Winter could have escaped any observer. If the corona is polarized radially, each image in an Arago's polariscope should be of uniform tint throughout any diameter but of complementary colors in diameters at right angles. Thus, if in one the N. and S. parts were red, the E. and W. parts would be green, while these colors would be reversed in the other image. So marked an effect could scarcely have been passed unnoticed by the four observers who used this instrument, had the polarization been intense. We must therefore regard it as beyond the power of this instrument, although it might still be detected by a Savart's polariscope, which is much more delicate. Arago and Mauvais appear to be the only ones who detected polarization within the moon's disk, while Prazmowski and Winter obtained precisely opposite results as regards the comparative intensity of the polarization in the bright and faint parts of the corona. Our knowledge then of this subject is still, therefore, very limited, and further observations are much to be desired.

Mass. Institute of Technology, Oct. 29th, 1870.

ON A BLOW-PIPE ASSAY WITH THE AUTOMATIC AIR-BLAST.

By Le Roy C. Cooley, Ph.D.

The blow-pipe furnishes an easy means of detecting the presence of precious metals; but, for reasons shortly to appear, its use has been, for the most part, limited to this purpose, and the furnace has been resorted to whenever a determination of the value of the ore has been desired. The simplicity and elegance of the blow-pipe assay have, however, prompted many attempts to make this instrument take the place of the furnace. Systems of quantitative analysis, with it, have been devised by Plattner and others, which, in the hands of skilful operators, do, doubtless, give satisfactory results, but they have never become popular with assayers. The objections to these methods do not spring from any want of confi-

dence in the chemical actions involved—these are satisfactory—nor do they arise from the amount of labor required, for this is less than that of the furnace assay. The objection to the use of the blow-pipe in determining the value of ores springs from the necessity of using such small quantities of ore that the silver button obtained is too minute to be satisfactorily valued. Rarely will this button be large enough to be weighed; its value is sought by measuring its diameter and comparing it, with that of another button whose value is known, on the principle that spheres are to each other as the cubes of their diameters. Delicate and ingenious scales have been devised for this purpose. But even if we allow that these minute diameters are, in any case, measured with sufficient accuracy, yet there still remains the fact that the little buttons can never be exact spheres, and it may well be doubted whether they ought to be considered as being truly similar solids.

If, then, the blow-pipe is ever to rival the furnace in assaying the ores of the precious metals, the first thing to be secured is the ability to operate with it upon larger quantities of material. For this purpose a larger flame must be obtained, and this necessity requires that the lips of the assayer be relieved from the fatigue of furnishing the air-blast. An automatic source of air is indispensable. If, however, the proper proportions of air and gas be furnished, it is no more difficult to produce a very large flame with oxidizing and reducing power, at will, than it is to obtain the ordinary blow-pipe flame possessing these powers. Such a flame once obtained, will evidently be able to bring about the proper chemical reactions in a large mass, with as much elegance and accuracy as the mouth blow-pipe flame does in the small quantity usually employed, and with much less labor on the part of the assayer.

The apparatus lately described in this *Journal* (October, 1870)—the *automatic air-blast* for laboratory purposes—furnishes exactly the kind of air-current necessary to produce the desired flame. With a Bunsen blow-pipe, provided, as it is, with an air jet in addition to the ordinary gas jet and collar of the common Bunsen burner, and with this automatic blast, gentle or strong at will, but always steady, the assayer has such complete control over the proportions of air and gas in his flame that he is able to regulate its heating, oxidizing and reducing power at his pleasure. With a flame so reliable in these respects, and at the same time so large as this one may be made, the assayer is able to scorify and

cupel a quantity of ore quite as large as would be taken for the furnace assay. The ordinary scorifying dishes and cupels of the furnace assay are used, and the same proportions of assay lead and fluxes may be employed.

The heat of the flame is sufficiently intense to keep the scorifyer and cupel in a glow without assistance from other sources, but if these vessels are placed over the flame of a laboratory lamp, its heat will facilitate the operation by allowing the energies of the blow-pipe to be directed more exclusively to the chemical actions which it is required to produce. Moreover, if the supply of water and gas is abundant, a blow-pipe with two or three jets can, doubtless, be made and fed, whereby as many assays may be simultaneously conducted.

That the accuracy of this blow-pipe assay is quite equal to that of the furnace assay, has been found by repeated comparison of results obtained from the same ore by the two methods, Indeed, the accuracy, neatness and simplicity of the method, together with the cheapness of the apparatus required, seem to justify this public description, and the hope that it will not be entirely unwelcome.

THE SUN.

(A course of five lectures before the Peabody Institute of Baltimore, January, 1870.)

By B. A. Gould.

(Continued from Vol. LX., page 423.)

Now, as for the spots. It is said that seven cities contended for the honor of having given birth to Homer. Almost, if not quite, as many claim the invention of the telescope,—yet there is small room for doubt that the first published account of such an instrument was in Holland, in October, 1608, and that the knowledge of its existence found its way only gradually through Europe, rumors of its existence meanwhile stimulating to independent inventions of the same wonderful contrivance.

No sooner had this new implement of research been turned upon the sun than it of course revealed the spots conspicuously to the observer. It is related that at a yet earlier date, the existence of solar spots had been known to the Chinese and to the Peruvians, and that one of the ancient Incas had not scrupled to express his

doubts as to the divinity of the sun, after seeing a large spot upon his face. But our first authentic accounts of them come from John Fabricius, a native of Friesland, who had a Dutch telescope at Wittenberg, with which he discovered a solar spot as early as February, 1611. In June of that year he published a little treatise* about them, and showed that they moved round the sun. Not more than a couple of months later, Scheiner, at Ingolstadt, of whom I have already spoken, and who was the first to avail himself of colored shade-glasses, also saw them;† and about the same time, probably, or a little later still, Galileo at Florence found them likewise.‡ A sharp discussion arose between Galileo and Scheiner, as to the priority of discovery: but it seems pretty clear|| that each, without knowledge of their detection, either by the other, or by Fabricius, had discovered the spots as early as April or May, 1611. The announcement that even the sun, the fountain of light, was not without its blemishes, was received with general incredulity.§ Scheiner did not venture to publish his results otherwise than anonymously—"not wishing," as he afterwards said, "to connect his name with a matter so unexpected, and to many so suspicious." Even eight years after the publications of Scheiner and Galileo, a French priest, Jean Tarde, undertook to prove¶ that the spots were simply planets, revolving around the sun, and, in that spirit of adulation which is not yet extinct, he baptised them the "Bourbon Stars." They could not be spots, he said, for the sun—the eye of the world—could not have the ophthalmia!"

To explain the phenomena of the spots, Domenic Cassini, the same astronomer whose determination of the sun's parallax was mentioned in the last lecture, suggested** in 1671 that the sun's surface must be an ocean of light, surrounding the dark solid central body of the sun, and whose tumultuous agitation sometimes discloses some mountain summit, which appears as the black nucleus of the spot. This suggestive idea formed, however, only

* *Narratio de Maculis in Sole observatis.* Wittenberg, 1611, June 4. 5 pp. qto.

† *Apelles latens post tabulam.* (Three letters to Mark Welser.) 1612, Aug. 5.

‡ *Discorso intorno alle Cose que stanno in Acqua.* Florence, 1612.

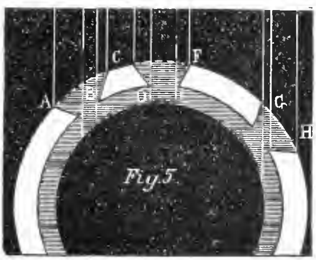
|| See Arago. *Annaire pour l'an*, 1842, p. 465.

§ Winnecke, "*Ueber die Sonne*," p. 11, states that there is evidence that both the Chinese and the Peruvians have recorded, at an earlier date, the existence of spots visible to the naked eye.

¶ *Borbonia Sidero*, etc. Weidler. *Hist. Astron.* p. 623. *Kosmos*, III, 408.

** Delambre. *Hist. de l'Astron. Moderne*, I, 387.

a first step toward the solution of the problem—the honor of which belongs to a Scotch astronomer, Prof. Alexander Wilson, of Glasgow, one hundred years later. Wilson observed* that the penumbra, or grayish border, which surrounds the dark nucleus, and which is generally of about equal width on all sides when the spot is near the middle of the sun's disk, always became narrower on the side nearest to the middle of the sun, when the spot approached the circumference. Hence, he inferred, in 1773, that the spots were funnel-shaped apertures in the luminous envelope, which disclosed the dark body of the sun at the bottom, and whose shelving sides constituted the penumbra. A moment's inspection of the diagram will show how such an aperture would, at the middle of the disk, exhibit the full size of the nucleus, D. E., and an equable border, represented by the apparent breadth at C. D. and E. F. of the inclined sides of the opening; but that when it is nearer the circumference, as at A. B. or G. H., the nearest side becomes foreshortened, as does also the nucleus, though to a less extent, while the farthest side of the aperture is presented much more fully to the view.



If, therefore, the appearances be as stated by Wilson, the inference seems irresistible that the spots are openings in the glowing envelope of the sun. This view was long accepted without doubt, but it has in recent years been called in question; and to make sure of the facts in the case, the Directors of the Kew Observatory have carried out an extensive examination of all the drawings and photographs of solar spots which they could make available. They had a valuable series of drawings and measurements made by Carrington in England, and extending over nearly seven and a half years, all on a scale of one foot to the sun's diameter; they had the magnificent collection of drawings made during forty years by Schwabe, in Germany; and furthermore, a series of photographs taken under M. De La Rue's superintendence, during nearly four years. Applying to these materials the statistical method, which is eminently adapted for an investigation where so large numbers are available, and measuring the relative dimensions of the penumbra on each side, they obtained the following results:—Considering

Phil. Trans. 1774. LXIV, Pt. 1, p. 6.

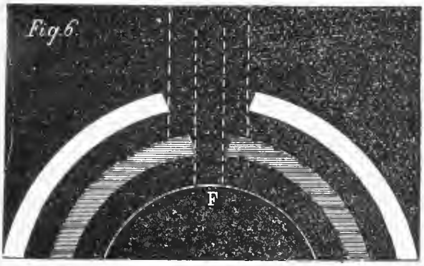
the spots only with reference to their position right and left of the central meridian line of the sun, they found, out of 605 cases, only 71 in which the penumbra was widest on the outer side; while out of 89 spots measured with reference to their position north or south of the sun's equator, there were but 17 which failed to exhibit the same conformity with Wilson's theory. This enormous preponderance of observations in its favor must be regarded as doing much toward settling the question: and we must infer that of those few cases which do not appear to support this theory, the explanation is to be found in an actual inequality in the width of the penumbra on the two sides, too great for the marginal foreshortenings to counterbalance. Mr. De La Rue has also suggested the use of the stereoscope for deciding whether the spots are actually cavities or depressions. Photographs of the spots, taken at different moments, with an interval sufficient to present them in an appreciably different position, give, when viewed in the stereoscope, an unmistakable appearance of indentations. But this argument, although a strong one, can hardly be deemed conclusive, inasmuch as our senses are often trickey guides, and things are not always what they seem. A stronger evidence of the sort is afforded by a photograph of the Kew series, which exhibits a notch in the circumference of the sun corresponding to the point of disappearance of a spot.*

But why should the sloping side of such a cavity manifest that diminution of the solar lustre which the penumbra exhibits? Because the darker body of the sun would be partially seen through, would be our first reply; but a moment's thought will show that were this the true explanation, the penumbra would exhibit different degrees of luminosity, and shade gradually away from full brightness at its circumference to darkness at its inner margin. This is not the appearance, but, on the contrary, the boundaries of the penumbra are sharply and distinctly defined, and its color is tolerably uniform throughout. To meet this difficulty, the German astronomer, Bode,† assumed a second envelope, of a cloudy nature, snpported by an atmosphere, and situated between the true body of the sun and the photosphere, as the outer light-giving envelope is called. The reflection of the photosphere from the surface would account for all the light of the penumbra, while the nucleus of the

* *Comptes Rendus*, LXVII, 1009.

† *Beschäft. d. Berliner Gesellsch*, etc., II, 237; *Kosmos* III, 410.

spot would be the body of the sun, as seen through the opening in this second envelope. The structure would then be as represented in this diagram, where A. B. represents the bright outer envelope, and C. D. the intermediate one, shining only by reflected, light and screening the dark body of the sun, E. G., excepting at the point F.



A C E G D B

Twenty years later, when the great William Herschel came to study these phenomena, he arrived at results* essentially the same as those of Bode; but he added the idea that the transparent elastic atmosphere, in which the stratum of clouds must be suspended at a height of some thousands of miles, likewise supported and extended beyond the photosphere. And to the action of this elastic fluid of unknown nature he attributed various phenomena observable at this outer surface. Emanating from the true surface of the sun, this gaseous atmosphere streamed upward, displacing the material of the surrounding cloudy stratum and of the thinner photosphere. It is a curious fact that a hypothesis almost identical with this theory of Herschel had been propounded as early as the middle of the fifteenth century, before the existence of the spots was known to astronomers; yet this must be regarded rather as a fortunate guess than as a scientific theory, for the evidence by which alone this view can be supported was not then known.

The general aspect of solar spots will be seen from the representations in Plate II.† The irregularity of their outlines almost defies

* *Philos. Trans.* 1795; 1801, pt. 2, pp. 270, 318.

† This Plate is an actual photographic reproduction from a series of negatives, made by Mr. L. M. Rutherfurd, of New York, showing the changes undergone by a remarkable spot on seven consecutive days

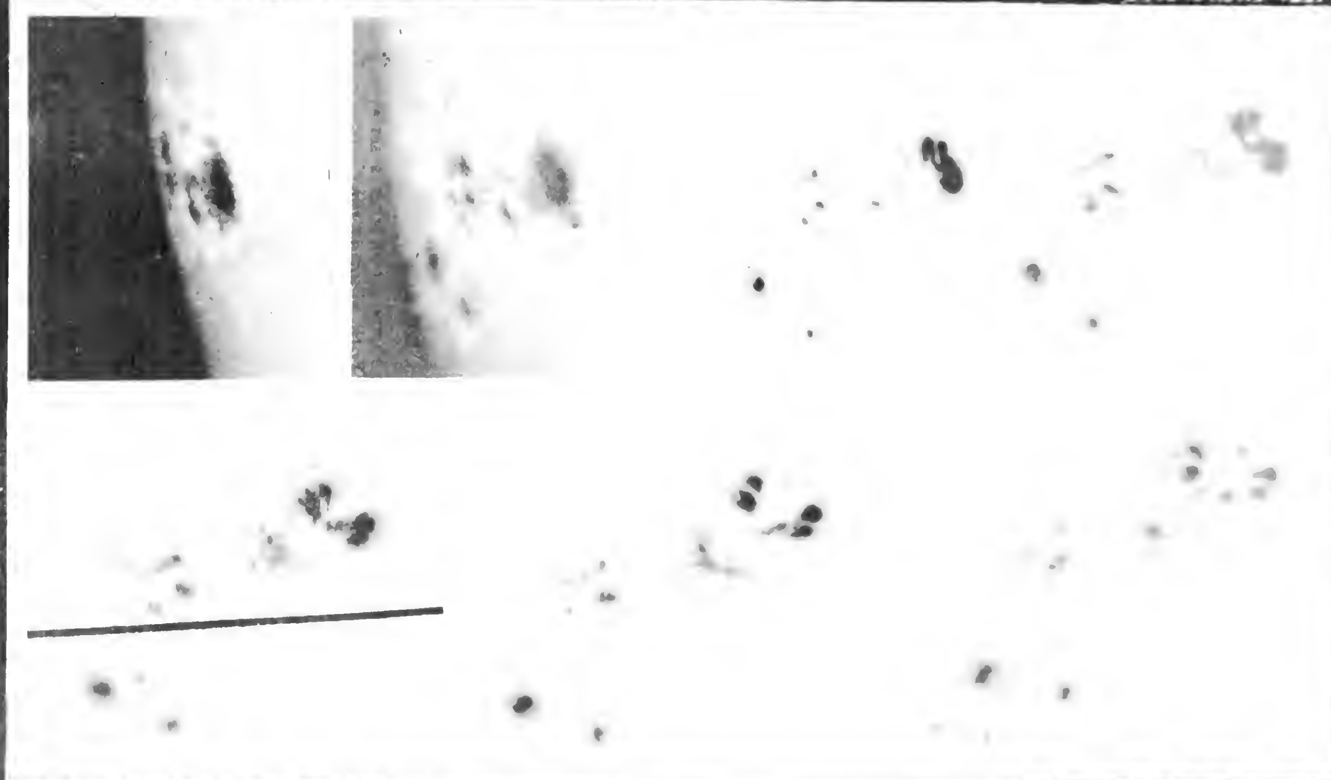
The exact dates of the series of pictures given in Plate II, are as follows:

							Sidereal Time.
1	September	19th,	1870	9h	·06m	·15s.	
2	"	20	"	9	·00	·00	
3	"	21	"	15	·00	·00	
4	"	22	"	9	·52	·10	
5	"	23	"	9	·27	·50	
6	"	24	"	11	·44	·55	
7	"	26	"	8	·26	·30	

Between 6 and 7 the interval is of two days, the intervening one having been cloudy. The black line on 5 gives the true east and west direction, which is the same in all.

The preparation of this plate was as follows:—Enlarged positives on glass were made from the 7 original negatives, and the required portions were cut out with a diamond in rectangular plates. These were then set together in order, and negatives were made from them, which, with strips of paper to cover the irregular marks produced at the lines of junction in the composite positive, were used in printing the necessary edition of this plate.—EDS.

The Sun. Pl. II.



Phot. by L. M. Rutherfurd.

Printed by J. Cremer.

description, and it must be remembered that the outline is under-going continual change.

The enormous magnitude of some spots has been already mentioned—huge chasms, which cover an area of some two billions of square miles, and whose mouths would receive at once forty or fifty globes as large as our earth. Their continual and rapid changes of form and size make it peculiarly difficult to settle many interesting questions concerning them, but decided indications of rotary motion have been observed in many of them, which would imply that, to some extent at least, they were turning like huge whirlpools around their own centres. The nucleus—although we speak of it as black, and although it appears intensely so in contrast with the glowing radiance of the surrounding portions—is in itself by no means devoid of brightness. Herschel endeavored to estimate the comparative light from the penumbra and nucleus, and came to the conclusion that the penumbra possessed in general about 47 per cent., and the nuclues about $\frac{7}{10}$ths of 1 per cent. of the luminous power of the solar surface. More recently, Chacornac has arrived at not dissimilar results, and it has been well said by Winnecke* that, were the light of the whole sun to be extinguished, excepting that portion radiating from the nucleus of a spot, our eyes would scarcely be able to endure the dazzling beams. Herschel's estimate has generally been regarded as too low, yet it would give to the dark nucleus of a spot a luminous intensity nearly 2500 times greater than that of the full moon. When Schwabe observed the transit of Mercury, in 1832, he was astonished† at the blackness of the planet as seen against the nucleus of a spot as a background. But a late English observer, Mr. Dawes, has pointed‡ out that even in the nucleus there are often places blacker than the rest. and for these he would reserve the name *nucleus*: calling the other portion only by the name umbra, or shadow. Perhaps it may be needless to mention that, to account for this appearance, still another solar envelope was summoned into existence, in the same way that one had been improvised for each of the preceding grades of brightness observed; and in the new theory what is seen as the umbra becomes a third envelope, while the darker points observed in it are to be regarded as the true body of the sun.

(To be continued.)

* *Ueber die Sonne*, p. 31.

† See, also, *Astron. Nachr.*, LXIV, 130.

‡ *Monthly Notices, R. Astr. Soc.*, XXIV, 36, 57.

Bibliographical Notices.

The American Journal of Science and Art.—This journal, the oldest of American serials devoted to Science, closes its first century of volumes with the current year, and the proprietors announce that it will hereafter be continued as a Monthly Journal. We believe this change is a wise step on the part of our esteemed contemporary, as it affords authors opportunity for a more rapid announcement of the results of research, and a more frequent interchange of ideas; while its readers will be so often reminded of the existence of the journal that they will always have it in mind. From 1818 to 1846 this now venerable journal was a quarterly, to the end of its first series of fifty volumes. It then became, with the accession of Prof. Dana, a bi-monthly, and has so continued until now, its November number, 1870, closes the second series and the first century of volumes. Its proprietors have not, we are well assured, mistaken the wishes and feelings of the many scientific workers and teachers in this country, in their proposed more frequent visits to the libraries, cabinets, laboratories and workshops of Science. The great body of its original readers have passed away with its venerated Founder, but their numbers in the country at large have been made good many fold with the increase of wealth and population, and all should be among the subscribers. *Silliman's Journal* has, from its commencement, been the leading vehicle for the original papers of American scientists, and we feel well assured that the friends and patrons of Science will take pleasure in promoting the wider circulation of a journal which is indispensable to all who would keep up with the progress of this country, and which has done so much to promote the cause of Science, and to advance our national reputation. The opening of a new series in monthly parts should remind all that now is a favorable occasion for commencing a subscription. It is published by Messrs. Silliman & Dana, New Haven, at six dollars a year.

JOURNAL

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OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXI.] FEBRUARY, 1871. [NO. 2.

EDITORIAL.

ITEMS AND NOVELTIES.

Illinois and St. Louis Bridge.—In Col. Eads' report we have a full description of the Ice Breakers, which it was found necessary to construct. We infer from it likewise the inference that its construction was coupled with unusual difficulties. He says: "The lateness of the season when the sinking of the east pier commenced, made it absolutely necessary to provide some adequate protection for the requisite boats, machinery, &c., at the site of the pier, against the heavy floating ice which invariably makes its appearance here during the winter.

The freezing over of the river at St. Louis is not, however, an invariable rule, as it does not occur, perhaps, oftener than three in every four years on an average. Last winter was fortunately an exception to the rule. For several days, however, the floating ice was so heavy and compact that it was with the utmost difficulty

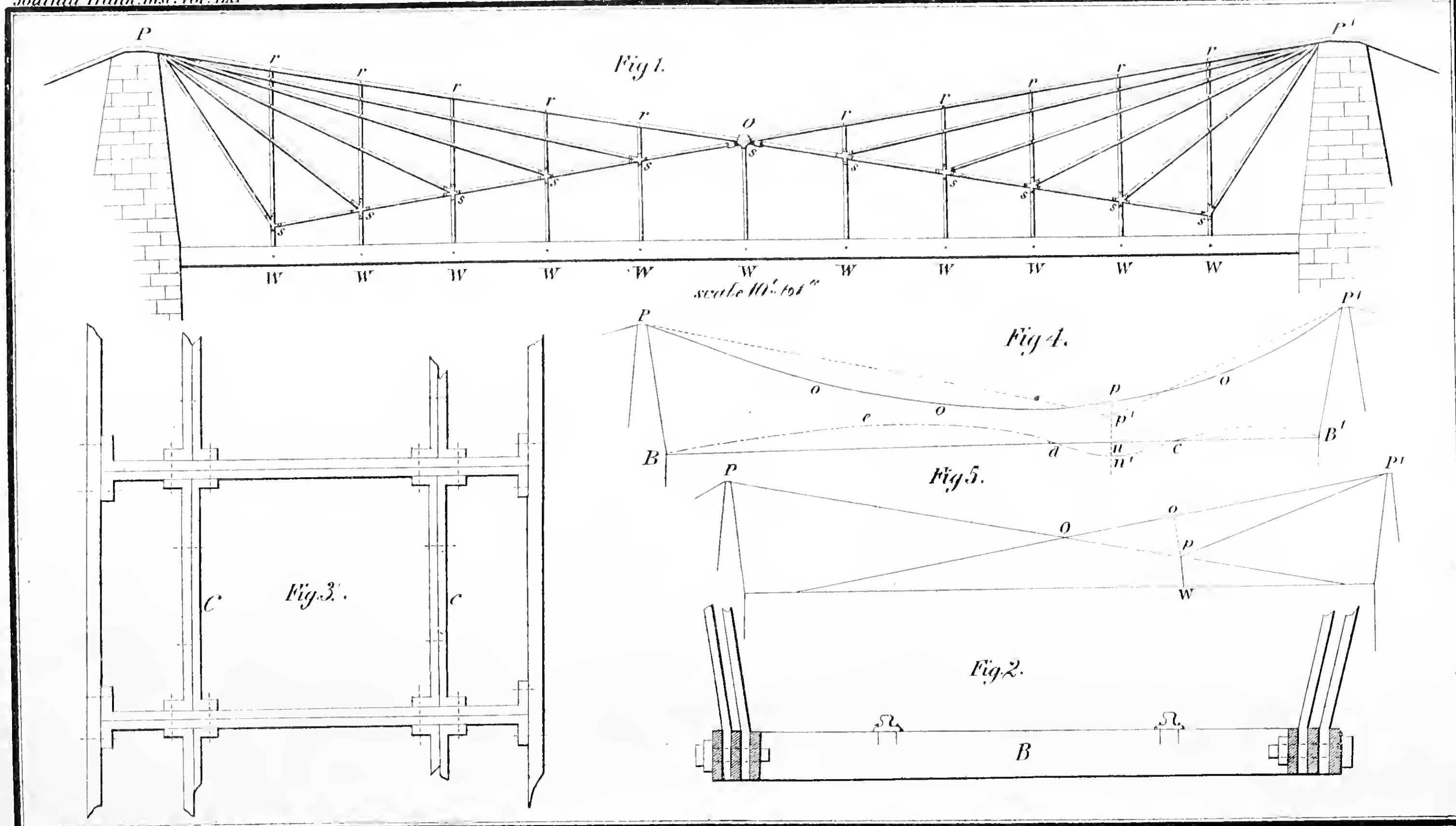
that the most powerful steam ferry boats, built expressly to meet such contingencies, could force a passage through it. One or two trips across during an entire day, being all that they could accomplish, frequent attempts in the meantime proving abortive.

To establish in mid-channel any temporary works to withstand an element so apparently resistless, and of such exhaustless volume, was an untried experiment on the Mississippi that presented several very discouraging features. The two chief difficulties were first, to place any construction above the pier that would not be quickly scoured out by the current, and second, to make such construction so strong as to resist the power of the ice to sweep it away."

The difficulty was, nevertheless, after great labor, successfully met by the construction of a triangular system of piles, which were protected from the direct impact of the ice by enormous ice-aprons, which, presenting an inclined surface to the ice, rendered it harmless, the ice sliding up on it, and breaking to pieces, as the soil is treated by the plough-share. This structure, the report further informs us, sufficed to completely turn the ice during winter, and made a thorough protection to the works and barges about the pier.

Triangular Suspension Bridge.—We place before our readers in this issue a plate illustration of the plan of a triangular suspension bridge. The principle involved in this bridge will be readily comprehended by an examination of Figs. 4 and 5. In Fig. 4 P *o o* P′ represents the cable of the usual suspension bridge. B B′ the roadway. When any extra weight is brought upon the bridge at any point as *n*, the roadway at that point is depressed, say to *n′*, the point *p* descending to *p′*, from the points *c* and *d* to each end, the roadway is elevated, between the points it is depressed. The cables tend to the lines P *p′* and P′ *p′*, while the roadway tends to assume the form B *e d n′ c* B′. This variation in the forms of the cable and roadway lines moves from point to point along with the extra weight. To obviate this a heavy truss is generally used. Now, in Fig. 5, if the weight be transmitted in a vertical line to *p*, thence in straight lines to P and P′, there can be no depression. The roadway will remain firm. This principle of transmitting the weight directly and in straight lines to the points of support is the main feature of this bridge. In Fig. 1, P and P′ are tops of piers, W W, &c., main chord of roadway, WS WS, &c., suspending rods or cables, SP and SP′ tower cables. The weight W transmitted

Triangular Suspension Bridge.



directly to S in each case, thence directly to P and P′. To keep the cables straight the main ones OP and OP′ rest on the top of sustaining rods *r s*, *r s*, &c., to which the minor cables are also attached to keep them straight also. Rails can be laid on the transversal roadway bearers as represented in Fig. 2. B being elevation of the bearers, the rail being represented in section resting thereupon, with supports between as in Fig. 3; *c* and *c* being the plan. With proper horizontal bracing a train of cars could be run over this bridge with safety.

The cables can be made by using steel wire, or parallel flat bars of steel or wrought iron. But it is not intended in this article to indicate any peculiar details of construction.

There would be great gain in cases where the main cables could be constructed partly below the roadway, so as to shorten O W as much as possible, thus lessening the angle P O W.

East River Bridge.—The excavations in the caisson of the East River Bridge have lately been progressing through a bed of stiff plastic clay. The accident of a workman having ignited a portion of the wood work—the compressed condition of the air in the chamber supported the combustion with an energy, which placed the ordinary means of its extinguishment out of the question—and seriously imperilled the caisson. The men were, therefore, allowed to ascend, the operation of the compressors suspended and the air within the chamber allowed to return to its normal pressure. It was naturally expected that when this had been effected, the pressure of the water from without would force it beneath the somewhat raised edges of the chamber, and rapidly fill it. To their surprise nothing of the sort occurred; but the chamber remained as free from water as when the compressors were in operation. The plastic and impervious material through which the excavation had been for some time progressing, had packed itself so completely about the outer shell that the water was completely excluded. It was found necessary to extinguish the flames to call into requisition the services of the Brooklyn fire department.

Blowing out Broken Piles.—Four piles driven for the "Cushing Piers" of the Connecticut River Bridge on the Shore Line R. R., during the winter of 1868–9 were broken off by ice, and after trying various plans for drawing them without success, the engigineer, Mr. J. Albert Monroe, succeeded in lifting them by driving a 4-inch gas pipe with a solid steel point, well down beside the piles

by means of a sliding ring arrested by a shoulder on the tube, and then introducing a charge of four pounds of powder to the lower end of the pipe and firing it. The piles were at once thrown out by the explosion.

Self-oiling Loose Pulley.—This invention consists of a porous wooden bush, B, secured oil-tight in the chambered hub of a loose pulley. The fast hub, D, is recessed to receive the bush, and the other end of bush is held by the counter hub, C, which is fastened to chamber by bolts.

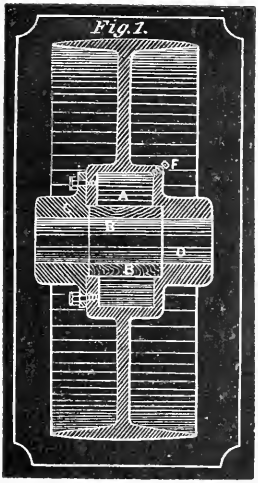


Fig. 1.

The bore of hub and bush are the same, and fit the shaft in the ordinary way.

The cavity A is charged with oil through the screw plug hole, F, and there is no escape for it except through the pores of the wood. The more volatile parts of the oil being held in an air-tight cavity, are therefore retained, and the oil is preserved thin and limpid for a great length of time.

This arrangement was patented by J, Goodrich and H. J. Colburn, May 4, 1869, and is shown by Fig. 1.

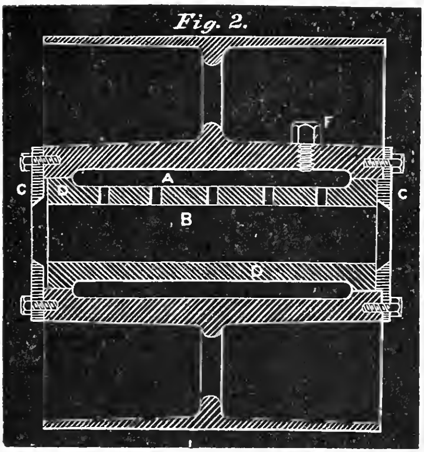


Fig. 2.

Fig. 2 represents another form of self-oiling loose pulley, the patent of W. W. Crane. June 4, 1867.

In the chambered hub is placed the metallic bush, D, bored through and through to fit the shaft, and fitted tightly at its ends to the bored ends of the pulley hub. To each end is secured a ring, C, with conical central hole.

The oil chamber, A, is filled through the screw plug, F, and reaches the shaft through openings drilled in the bush. J. H. C.

Tinning of Iron, &c.—We append below an account of a process for tinning copper, brass and iron at the ordinary temperature,

and without the assistance of mechanical devices. The paper appears in *Dingler's Polytechnisches Journal*, and is from the pen of F. Stolba, an indefatigable worker in the field of technical chemistry. It is first necessary to thoroughly cleanse the surface to be tinned, which may be accomplished either by the ordinary mechanical process of turning or by chemical means, care being taken to remove any trace of grease.

The efficiency of his plan depends entirely upon a chemical principle, namely, the reduction of a salt of tin, to the metallic state by a more electro-positive metal. The reduced tin is deposited all over the surface to be coated in a highly divided state, and is subsequently made to adhere strongly and to assume a fine polish by friction. The substances employed are finely pulverized zinc and a carefully prepared solution of protochloride of tin (readily formed by treating an excess of tin with hydrochloric acid), to which has been added a trifling amount of bi-tartrate of potassa. The surface to be coated is first entirely moistened with the tin solution, with the aid of a sponge or other suitable material, and directly afterward some of the zinc powder is similarly taken up and rubbed upon it. The tin is reduced by simple substitution. The zinc robbing the tin of its chlorine, and the metal thus separated depositing itself in a state of the finest division all over the surface of the object thus treated. When the tinning is satisfactorily accomplished, the surface is washed with water and finally polished with chalk powder.

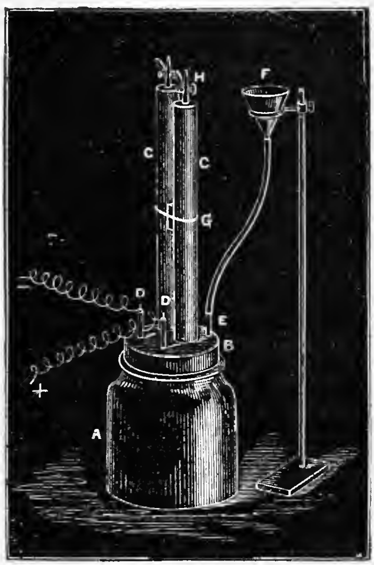
A new Lens.—At the last meeting of the Optical Section of the Institute, the feature of the evening was the first exhibition of lens of peculiar combination and construction, designed by a member of the Section, Mr. Jos. Zentmayer, the well-known optician, expressly for use with the gas microscope. The object upon which the designer has bestowed especial care has been to obtain in practice the largest possible aperture with the best equalized field.

In order to meet the case the lenses in the combination are placed in such positions as to transmit the rays as nearly normal as possible to the surface of each member of the group. The performance of the new lens was tested by comparison with that of an excellent Zentmayer lens of the ordinary construction. The power of the new lens was equal to $1\frac{1}{2}'$, with a full aperture of $\frac{7}{8}'$ (a relation which could be expressed by $\frac{f}{1 \cdot 764}$), while the other possessed the same power with $\frac{1}{2}'$ aperture $\left(\frac{f}{3}\right)$. The quantity of light, there-

fore, received by the two lenses would be represented by the ratio of 49 : 16 or about 3 : 1. The comparison was instituted with the same objects under the same conditions; the results are therefore reliable, and we are pleased to say fully met the expectations which had been formed of them. The image formed by the new lens possessed nearly, if not quite, three times the brightness of the other, while the deviation from perfect flatness of field was inappreciable.

On a cheap form of Voltaic Decomposition Apparatus.* The decomposition tube devised, I believe, by Dr. Hofman, and described at p. 50 of his "Modern Chemistry," is an extremely elegant and luxurious piece of apparatus for showing analysis of bodies by electricity; but it has two defects, viz: that it is expensive to begin with, and very easily broken, either during its carriage or by the mischances of the laboratory assistant. Experience of the fragile character of these tubes led me to make a more substantial apparatus, which, while it has the advantage of the ordinary tube. can be fitted up in any laboratory for a few shillings. The following is a description of the arrangement:

A is a common pomade bottle, into which is fitted an india-rubber stopper, B, perforated with five holes (two large, two small, and one medium size.) Though the two large holes of the stopper pass two glass tubes, C C, of about $\frac{1}{2}$-inch diameter and 7 or 8 inches length. Each of these tubes is closed at the top by an india-rubber stopper carrying a piece of $\frac{1}{8}$-inch glass tube, to which is attached a jet and pinch-cock, H. The electrodes are made as follows:—A piece of thick platinum wire is beaten out at one end to form a flat plate, and is then threaded through a piece of glass tubing rather shorter than itself. When this is done, the glass is melted on to the platinum, and the tube, with its contained wire, is bent in the form of the letter J



A second piece of wire and tube is treated similarly to form the

* From the *Chemical News*, communicated by the Editor.

second electrode. When these are made, they are passed through the two small holes of the stopper, B, and project above it, as represented at D D. The electrodes are turned so that they may pass up into the tubes, C C. To the remaining hole of the stopper is fitted a tube, E, connected with a piece of caoutchouc tubing with a funnel, F, supported on the ring of a retort stand. The apparatus is now complete, and when the stopper with its appendages is fitted into the pomade bottle, is all ready for charging. This is done by pouring the acidulated water or other electrolyte into the funnel, F, at the same time opening the pinch-cocks to allow the air to escape. When the bottle and tubes are full, the pinch-cocks are closed, and all is ready for attaching the battery to the electrodes at D D. I omitted to mention that the tubes, C C, may be conveniently steadied, should this be necessary, by tying them against a cork wedge, as represented at G. C. J. WOODWARD, B.Sc.

Compressed Air as a Motor.—In an able paper by Mr. J. F. Haskins, appearing in the *Engineering and Mining Journal*, we glean some interesting statements concerning the history of this subject. Mr. Haskins, who is an earnest advocate of the system, informs us that there exist three plans underlying its utilization as far as the subject has been developed. These are "the water column," "the piston immersed in water," and "the piston simply packed and lubricated by water or other fluids." Of the first class we are informed that there are several varieties, all, in the opinion of the author, containing in them the elements of success.

They operate upon the general plan of starting and stopping a column of water. Those at Mount Cenis are stated to have been very successful and economical. They have small engines actuated by compressed air, which operate the induction and eduction valves. They are placed at an inclination, drawing their supply of water from cisterns, thus insuring clean water. With them they compress air to sixty and seventy pounds to the inch, and sometimes more, as they may require. Other apparatus, depending on a column of water for its power, has been constructed, and there are several parties now experimenting in that direction.

Of the immersed class of compressors we are told that there are also several. They do well for low pressures, but not as well for high ones, the difficulty being that the piston, in moving, has also to move a large body of water, which, of course, absorbs an amount of power equal to its own inertia.

Concerning the vital point of transmission, the opinion is ventured, based upon extensive experience at the Hoosac Tunnel operations, that no difficulty is experienced.

The Naval Observatory Eclipse Party.—The preliminary reports of the observatory party of which, through the courtesy of Prof. J. E. Nourse, we are privileged to placed an early abstract before our readers, indicate a very fair degree of success. It should certainly be a source of sincere gratification to the followers of science in this country to know that two independent observing parties under the patronage and support of two different branches of the government were sent across the ocean in the interest of science. It indicates an intelligent appreciation in the "powers that be" of the sterling value of physical investigation. The observatory expedition is, we believe, mainly composed of the observers of last year's party, under the direction of the Superintendent of Naval Observatory, and detailed by the Secretary of the Navy. From the Coast Survey party, whose organization we mentioned in our January issue, we also have the pleasure of presenting some items of interest.

Facts Relating to the Distinctness of Sound.—The following statistics compiled by Mr. C. R. Moore, at the instance of the Smithsonian Institute, and kindly communicated by him are instructive in showing how the circumstances of locality may vary the distinctions of sound. In the tabulated list of observations which we append, the sounds which furnished the material were the "Sue's" whistle, and the report of the guns at Fortress Monroe. The distinctness of the sound, and the direction and force of the wind were noted, 10 representing the maximum of wind and sound. The point of observations is Prospect Hill. From this locality Fortress Monroe is distant 40 miles in a southwesterly direction. Cherry Stone 13, and Hungar's Wharf 8 miles also S. W. The country between the point of observation and Hungar's Wharf is wooded, and in mild seasons when the trees are in full foliage the sound is almost or entirely lost. The tables from May to October, present sharp lines of demarkation from the remaining months owing to this cause. The curious portion of the table will be found to be in the repeated recurrence of a strong sound, at times reaching even the maximum of distinctness in the teeth of a strong northeasterly wind. Directly the reverse would be expected under ordinary circumstances. Whether or not the country presents any

unusual features, to which this peculiar phenomenon may be referable, does not appear from our correspondent. The fact, however, is mentioned that the sound from Fortress Monroe must cross the Chesapeake Bay.

Prospect Hill, January 9, 1871.

1870.		Sound	Wind.	Force
Jan. 1.	Sue's Whistle Hungar's Wharf................	8	N. E.	1
	Also at Cherry Stone................................	1	N. E.	1
6.	Guns at Fortress Monroe............................	6	S. E.	1
8.	Sue's Whistle at Hungar's...........................	6	N. W.	2
11.	Guns at Fortress Monroe............................	2	E.	1
17.	Sue's Whistle at Hungar's...........................	8	S. E.	1
22.	“ “ “	2	S. E.	1
31.	“ “ “	8	N. E.	2
31.	Guns at Fort Monroe................................	8	N. E.	2
Feb. 4.	“ “ “	10	N.	1
17.	“ “ “	10	N. E.	2
20.	Sue's Whistle at Hungar's...........................	4	S.	2
25.	Guns at Fort Monroe................................	3	N.	1
26.	Sue's Whistle at Hungar's...........................	5	N.	1
Mar. 12.	“ “ “	4	S. E.	1
Apr. 7.	Guns at Fort Monree	6	N. W.	1
9.	“ “ “	4	S. W.	1
20.	Sue's Whistle at Hungar's...........................	6	S. W.	1
May 4.	“ “ “	1	N. W.	1
14.	“ “ “	1	N.	1
21.	“ “ “	4	W.	2
23.	Guns at Fort Monroe................................	1	S. F.	2
Oct. 8.	“ “ “	3	N. E.	3
10.	“ “ “	5	S. E.	1
11.	Sue's Whistle at Hungar's...........................	8	S. E.	1
12.	Guns at Fort Monroe	6	N. W.	1
19.	“ “ “	4	E.	1
25.	“ “ “ and Sue's Whistle......	1	S. W.	2
28.	Sue's Whistle at Hungar's...........................	1	N. W.	2
28.	Guns at Fort..	6	N. W.	1
Nov. 17.	Sue's Whistle at Hungar's...........................	6	W.	1
19.	“ “ “	10	N. W.	1
21.	Guns at Fort Monroe	9	N. W.	2
28.	Sue's Whistle at Hungar's...........................	8	N. E.	1
Dec. 3.	“ “ “	8	N. W.	3
5.	“ “ “ and Guns at Fort	4	S. E.	1
7.	“ “ “	10	E.	1
10.	“ “ “	6	N.	1
12.	“ “ “ and Cherry Stone	6	W.	1
17.	“ “ “	4	W.	1
19.	“ “ “ and Cherry Stone	6	N. E.	1
20.	Guns at Fort..	6	N. E.	1
22.	Sue's Whistle at Hungar's...........................	10	N. W.	1
28.	“ “ “	8	N. E.	1

Journal of the Franklin Institute.—January, 1868.—The demands for sets of the *Journal* have recently been so great as to

cause a serious diminution of the stock on hand. Especially does the management feel the want of the number heading this notice. In view of this fact we are prepared to pay 50 cents for every unmutilated copy of that number which is sent to the Hall of the Institute; and we would respectfully request any of our subscribers who may have a knowledge of the existence and whereabouts of incomplete volumes to aid us in enlarging our stock of the wanting number.

Compressed Leather.—Dr. Dingler.—The author states that offal of leather, cuttings, and scraps, are first cleansed from dirt and dust, then soaked in water containing 1 per cent. of sulphuric acid, until the material becomes soft and plastic, next compressed into the shape of blocks, dried by steam, and lastly rolled out in mills. In order to soften the mass, 1 pound of glycerine is added to 100 pounds of material. The leather thus again obtained is applicable for the inner soles of boots, &c.

Editorial Correspondence.

Jerez, December 23d, 1870.

PROFESSOR MORTON.

DEAR SIR:—By the courtesy of Professor Winlock I am permitted to communicate the general results of our observations of the eclipse. I think I may say that on the whole our expedition has been highly successful, and has fully attained the objects for which it was sent, although perhaps more might have been accomplished had the weather been better. We seem, however, to have been more favored even in this respect than any of the English parties which observed in Spain. I have not yet heard anything from the parties in Algeria and Sicily.

Our party of twelve concentrated at Jerez some 30 miles (by rail) north of Cadiz, about ten days before the eclipse, and although much interrupted by unfavorable weather our instruments were in position and adjustment in good season. Mr. Dean, assisted by Capt. Ernst and Mr. Gannett, had in charge the determination of

our geographical position, using a 46 inch transit, chronometer fitted with galvanic break circuit apparatus, a chronograph, sextant, &c. The photographic apparatus comprised two telescopes equatorially mounted with clockwork, one of 8 inches aperture, and the other of 6, besides a horizontal telescope of 5 inches aperture, and about 30 feet focus, with a plane unsilvered mirror of glass to reflect the sun's rays into the tube. Messrs. Willard, Mahoney and Gannett attended to this department.

Professor Pickering observed for the polarization of the corona with apparatus which I presume he has described in his letter to you. He was assisted by Mr. Ross. Professor Langley also observed for the same, and for the general features and structure of the corona.

We had four spectroscopes in the field. Professor Winlock used an instrument with two prisms. This was attached to an equatorial of 5½ inches aperture which formed a distinct image of the object observed on the slit of the collimator. Mr. Clark assisted him at the finder.

My own instrument was the spectroscope figured and described in a late number of the *Journal.* It was attached to the Dartmouth College Equatoreal of 6½ inches aperture, and like Professor Winlock's, received a distinct image on the slit of the collimator. The observations previous to totality, were made with the whole dispersive power equivalent to 13 prisms. During totality I used 7. As the observations of Professor Pickering last year had made it a matter of interest to observe the general spectrum produced by the total light coming from the moon's immediate neighborhood during totality, without any limitations such as are introduced by throwing an image upon the slit, two instruments were mounted for this purpose. The first consisted of the collimator and telescope of my large 9-prism instrument, with two of its prisms. The telescopes have an aperture of 2¼ inches, and a focal length of about 17, and the prisms are of proportionate size, having, however, an angle of only 45°.

This was mounted upon a board in such a manner that it could have the slit of its collimator readily pointed toward the sun. As its angle of aperture was about 7°, it required no great exactness of direction and no movement during the totality. This instrument was put in charge of Mr. Abbay, a member of one of the English parties, who, at his own request, was kindly detailed to

assist us in the matter, as they had no suitable instrument, and we no spare observer. He brought with him an induction coil and a Geissler tube, prepared under Mr. Lockyer's supervision, which gave the combined spectra of hydrogen, mercury, magnesium and sodium. This spectrum, thrown into the field of view in the ordinary way, formed the scale of reference. Another smaller instrument was fitted up from a star spectroscope of one prism of very dense glass, with telescope and collimator of the usual size—about 1-inch aperture and 7-inch focal length. To increase the light I placed in front of its slit a small telescope, magnifying about $2\frac{1}{4}$ times, and having a field of $3\frac{1}{2}°$. This was adjusted carefully for distinct vision on a remote object, and its effect was, *not to form an image on the slit* and thus to limit the locality from which the observed spectrum was derived to some small point, but merely *to increase the virtual angular diameter of the sun and the total amount of light received on the slit.* This instrument was put in charge of Mr. Pye, a young Englishman who was spending the winter at Jerez, for the benefit of his health. He had had some experience in spectroscopy, and used his instrument very skilfully and effectively. To all these instruments, excepting Mr. Abbay's, was adapted Professor Winlock's beautiful arrangement for recording the positions of the lines observed. A little chisel is brought down by the simple pressure of the finger, upon a silver plate which moves with the telescope, and thus a fine line is made which permanently marks the position of every line which may be upon the cross-wires of the instrument; these plates are preserved, and afterwards read off at leisure by a suitable micrometer. Besides those I have named, several English gentlemen joined us in general observations, and in making sketches and drawings of the corona. One of these drawings, from the pencil of Mr. Gordon, appeared to me in fidelity and beauty to equal anything I have ever seen,—but I anticipate.

The day and night previous to the eclipse were very fine, but early in the morning it clouded up. When we arose the prospect was very gloomy—it even rained from time to time. We made all our preparations, however, and before the first contact (10·25, A. M., local time) there were many patches of partly clear sky—but there was always, even when clearest, enough haze of frost crystals to cause the sun to be surrounded by a conspicuous halo of $22\frac{1}{2}°$ radius.

At the time of the first contact it was clear enough to allow good observations to be made in the usual method. I attempted to use the spectroscope upon it in the same manner as last year, but failed on account of the thin cloud which most of the time entirely obliterated the chromosphere lines.

Between the time of first contact and totality, there were several intervals of moderate clearness, in which photographs of the partial phases were taken. Just before totality the clouds became much thicker and we nearly gave up hope, but at the needed time, almost by the direct interposition of Providence, it would seem, a small rift in the now heavy clouds passed over the sun, and permitted us to see and observe the sublime phenomenon, if not in all the beauty and grandeur of last year, yet satisfactorily and most gratefully.

The details of its structure were not seen this year nearly as well as last by the telescopic observers. The thin cloud shaded out and obliterated definition, without, however, cutting out much light. I think, if anything, it appeared more extensive than then, but much less definite in its outline. Others, however, thought it much less extensive. Its form was, as usual, roughly quadrangular—nearly square; but it is a curious fact that its longest diagonal was neither equatorial nor polar, but made an angle of nearly 45° with the hour circle, lying from the N. W. to the S. E. This was carefully determined by Professor Langley. There was no prominence on the sun's limb which could compare in magnitude and beauty with the "anvil" of last year, but there were many small ones which were very bright and active.

Within 5 minutes after the end of the totality the sky was wholly clouded and we did not see the sun again till just at evening, after a heavy storm of wind and rain. During the totality one good photograph of the corona was obtained with the 6-inch glass, with an exposure of $1\frac{1}{2}$ minutes. It is of course by no means so good as it would have been had the sky been truly clear, but it shows a great deal of detail, curved filaments and radial shadings far better than any before obtained. The picture obtained with the 8-inch glass was nearly injured by not being removed until the sun came out. No attempts were made to photograph the prominences, which can be seen and studied at any time—all efforts were concentrated on the corona.

In respect to the polarization observations, I presume Professor Pickering has fully informed you. It would almost seem that there must have been some peculiar defect in the particular instrument he used last year, as his assistant, Mr. Ross, using the same identical apparatus which Prof. P. did then, obtained the same negative result. But apparently similar instruments used this year, conspired with others quite different in indicating radial polarization of the corona. The appearances in the instruments were much complicated by the cloud and haze, but I believe Prof. Pickering and Prof. Langley both agree that the corona certainly has a considerable proportion of its light radially polarized.

Our spectroscopic results completely confirm those of last year, except that the two faint lines which I saw between D and E last year, and suspected to be corona lines, as well as 1474, were not seen at all this time. 1474 was traced by Professor Winlock to a distance of near 20′ from the sun's limb. I traced it 16′ on the west, 12′ on the north, 14′ on the east, and about 10′ on the south. The principal chromosphere lines were also visible in the corona to a distance of 3′ or 4′. But Prof. W. and myself both agree in attributing these to the reflection of the haze around the sun. I am the more confident as to this, because last year in a clear atmosphere the C line was certainly sharply terminated at the upper limit of the chromosphere or prominence under observation. Mr. Abbay, in his spectroscope, saw only the 1474 line and the F line—the former considerably the brighter of the two. He saw no continuous spectrum.

Mr. Pye saw C (8·5); D_3 (5·5); 1474 (10) and F (3). The numbers appended represent the relative brightness of the lines. All of us, except Mr. Abbay, saw a faint continuous spectrum, but without any traces of dark lines. Still, as far as I am concerned, I should not dare to affirm that there might not have been dark lines without my seeing them, since on account of my using so great dispersive power this spectrum was very faint except when I widened the slit considerably. With the instruments of Prof. W. and Mr. Pye the case is different. I do not think, if dark lines existed, they could have escaped them.

No particular examination was made of the chromosphere spectrum, but I noticed it sufficiently to ascertain that there were probably in it, at least in the particular portion under observation, no lines which I had not already seen under ordinary circumstances.

I saw C, D_1, D_2, D_3, 1474, two or three of the iron lines near E, the four lines of *b*, two Barium lines between *b* and F, and one of the iron lines (often seen there), F, and 2185 which Mr. Lockyer considers a magnesium line. I did not examine the spectrum above this point, nor below C. This was on the eastern limb of the sun near the point of last internal contact.

Perhaps I may be allowed to interpolate here, that on the previous day I saw in the spectrum a very bright but small prominence on the N. W. limb of the sun, the line below C, which I have seen twice before, but have so often looked for in vain that I had more than half concluded myself to be deceived. It is the reversal of the dark line, 656, of Kirchhoff's map. Also, in the same prominence, and for the first time, I believe, the three *chromium lines* just below *b*. Of course, D_1 and D_2, and all the lines of *b*, were very bright in it, as well as many of the iron lines seldom seen.

But the most interesting spectroscopic observation of the eclipse appears to me to be the ascertaining, at the base of the chromosphere, and, of course, in immediate contact with the photosphere, of a thin layer, in whose spectrum *the dark lines of the ordinary solar spectrum are all reversed.*

Just previous to totality I had carefully adjusted the slit tangential to the sun's limb, at the point where the second contact would take place, and was watching the gradual brightening of 1474 and the magnesium lines. As the crescent grew narrower I noticed a fading out, so to speak, of all the dark lines in the field of view, but was not at all prepared for the beautiful phenomenon which presented itself when the moon finally covered the whole photosphere. Then the whole field was at once filled with brilliant lines, which suddenly flashed into brightness and then gradually faded away, until, in less than two seconds, nothing remained but the lines I had been watching. The slit was very close, and the definition perfect. Of course, I cannot positively assert that all the bright lines held exactly the same position that had been occupied by dark ones previously, but I feel very sure of it, as I particularly noticed several groups, and the whole arrangement and relative intensity of the lines struck me as perfectly familiar. Mr. Pye saw the same thing for an instant only. Prof. Winlock did not, as his telescope at the time, in accordance with his directions, was pointed to a spot at some distance from the sun's limb. Mr. Abbay did not see it.

This observation is a confirmation of "Secchi's continuous spectrum" at the edge of the sun, and, I think, tends to make tenable the original theory of Kirchhoff as to the constitution of the sun, and the origin of the dark lines in the ordinary solar spectrum.

I must not close this communication without a reference to the courtesy and kindness we received from the inhabitants of Jerez. Everything possible was done to assist us, and to make our stay agreeable.

Yours, very truly, C. A. YOUNG.

Jerez de la Frontera, Dec. 23, 1870.

DEAR SIR:—I wrote you from Southampton, enclosing a description of the polarising eye-piece, which I promised to supplement by a drawing, that I have been unable to find opportunity to make. Should you be able to make use of what I then sent, unillustrated, I shall be glad to have you do so.

Yesterday began with rain and clouds. Five minutes before totality the sky was overcast, and the sun quite invisible. A wonderful good fortune gave us a rift of blue sky at the critical place and time, and we did very fairly, though working partly through light haze.

Prof. Young (who, I suppose, has written you,) comes out well, having followed 1474 fifteen minutes from the sun, and three independent observers found it the brightest visible line.

Prof. Pickering and I were half a mile apart. Both of us saw what seemed evidence of radial polarization in corona, but the observation of the atmospheric polarization was difficult, and not, perhaps, conclusive, except as to the fact that this year's polariscope results show corona to be in part reflected light. How far this is due to absence of last year's cloudless sky I can't say. The corona was, to my naked eye, quite different from that I saw in Kentucky.

Mr. Willard has one good coronal picture, showing structural lines. I saw none of the striation apparent last year in telescopic scrutiny. We feel well content with our fortune, which is better than that of the English parties in our neighbord.

Very truly yours, S. P. LANGLEY.

Prof. Morton.

Civil and Mechanical Engineering.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 42.)

Science in its researches has left but few nooks in the industrial arts unexplored, every detail of shop manipulation, every conceivable application of mechanical forces, has, with but few exceptions, passed through the ordeal of scientific criticism and investigation.

Even the most simple matters have become the subject of abstruse mathematical calculation and are demonstrated in formulas that are a hundred fold more complicated than the operations themselves. This zeal to apply mathematics to our shop manipulation, or rather to all matters pertaining to mechanics has, no doubt, in a large measure, to be imputed to a recent realization of the fact, that they are intimately connected, are one and the same. Our shops in this country were, for the most part, founded on the "cut and try" principle; to start with, there was a popular distrust in *book* learned mechanics, and even yet in many parts of the United States there exists a strong distrust of any proposition relating to mechanics that is not based strictly upon experiment and shop demonstration. Such distrust was not without its reasons, as will be noticed further on.

But now that experience has found that the mechanics who rely upon scientific data, and who follow the laws of construction as laid down from the deductions of scientific men, are the only ones to succeed; it has not only awakened an interest but a pride in the amount of such knowledge possessed in our shops. This zeal to study theoretical mechanics is sufficiently attested in the number of polytechnic and other scientific institutions of learning of this kind that has sprung up in our country.

The discovery of the mechanical equivalent of heat has done much to restore confidence in the theoretical laws of mechanics. Without this philosophy a link in the chain was wanting; there was a stopping point to theoretical deductions about forces; much that could not be explained in a manner sufficiently rational to gain

the confidence of mechanics, when they had been educated to regard *book learning* on the subject as pernicious and almost unfitting one for the shop.

Everything in nature is the subject of fixed laws. To interpret them is the business of science, and to spread before the mechanic a chart on which he can rely. An apprentice who enters the shop with the impression that the business he is about to learn is something mysterious, and that he is to grapple about in the dark stumbling upon his ideas, solely from experiment, will never master his trade. There must be a fixed confidence in constant results; he must, to succeed, well know that all he is to learn is governed by fixed and unalterable laws which science has with the aid of experiment interpreted. That there is a tangible something which he can in time master, and that he can *learn his trade*, a proposition that would be untenable unless his business could be considered as a demonstrated art.

After this much in regard to scientific research in the mechanic arts, we intend to allude to a few things that seem to have been overlooked or forgotten.

In a previous article the counterbalancing of the reciprocating parts of machinery was alluded to with the promise that it would be taken up in connection with reciprocating saws. It was overlooked at the proper time but will not be out of place here. The subject of counterbalancing as applied to reciprocating movement is one of these *nooks* that seems to have escaped the scientific research that has been so lavishly expended on matters of much less importance,—a reason for this was no doubt set forth in the introduction to these articles when wood-working machines were placed in the same category. Aside from the reciprocating parts of the steam engine, the question of such counterbalancing is confined mainly to wood tools; not that cutting operations on other material is much the same, but it is only in wood-cutting that a high velocity is needed and a corresponding necessity for counterbalancing exists.

Counterbalances on saw mills and scroll saws is a theme as old as our country. Old millwrights who built our "log sawing" mills of rude and imperfect construction in the absence of anything but their personal judgment and experience to guide them had nothing of more interest to argue or differ about than counterbalances.

A journal claiming to be scientific has, to within a few months past published numerous communications on the subject of such counterbalances, containing a diversity of opinions which prove conclusively that there are no scientific data to determine the matter, at least in any form that is available to mechanics generally, and justifies the assumption that one important feature in construction has been overlooked in our voluminous text books.

Another thing intimately connected with counterbalancing rotary and reciprocating parts of machines, is centrifugal strain. What should be the diameter of a bolt that will safely hold a cutter weighing one pound revolving 1000 revolutions per minute in 24 in. circle, is a question that would be difficult to answer from any text book that has come to the knowledge of the writer.

Such questions are of vital importance in the construction of wood machines, where there is great danger attending their operation even when the greatest judgment is used in attaching cutters and other details that have high motion.

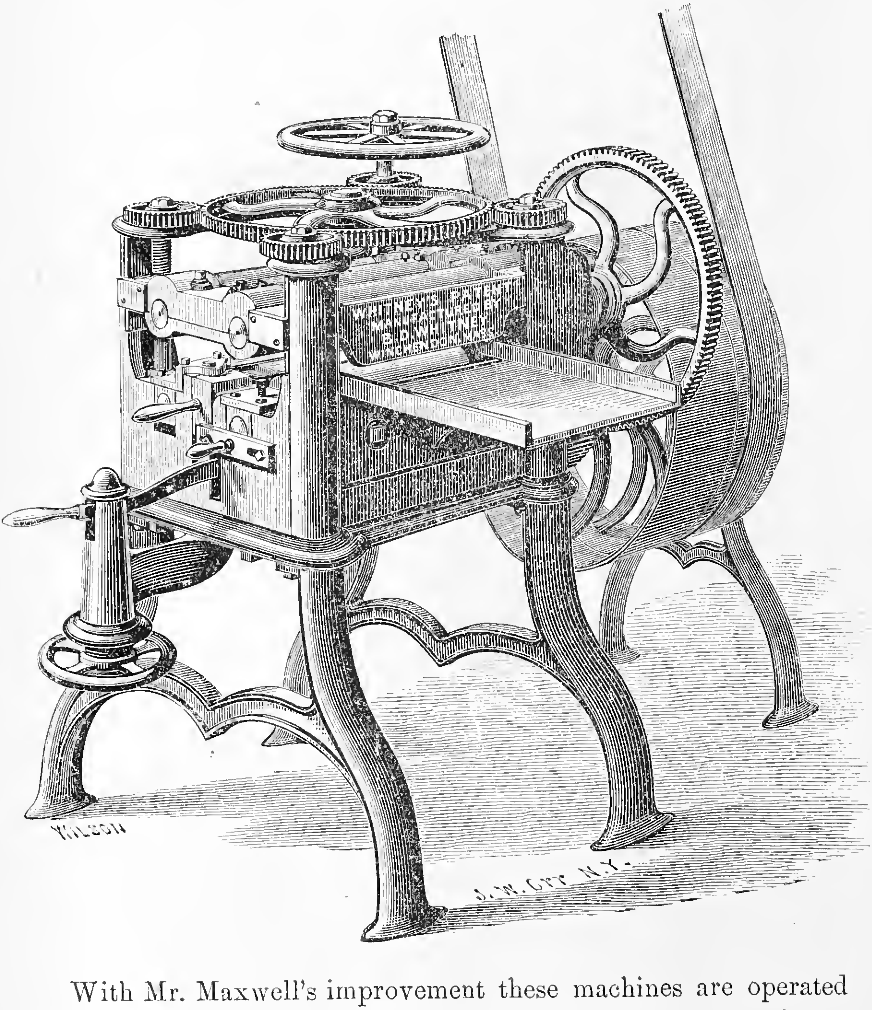
To a question as to where a cutter was that was thrown out of a machine in motion. The writer received the following reply from the man who was operating it, "It is enough to know that it did not go through me. I never yet saw a cutter that came out of *that* machine." Numerous and serious accidents arise from imperfect fastenings for cutters in wood machines, and argues a necessity for some more reliable standard than that of mere judgment.

A patent granted to Captain John Ericsson during his *Monitor* career for counterbalancing the reciprocating parts of machines, was about the first published matter that directed attention to the true theory of counterbalances in this country. It was comprehensive, and showed the acquaintance of this celebrated engineer with the matter. It related in substance to counterweighting the reciprocating parts of machines by means of balances of equal weight with the parts, having a coincident movement in a reverse direction; or of weights greater or less with a proportionate range of movement, inverse of course. These may not be the precise words of the patent, which is quoted from memory, but are the claims in substance.

In 1866, about the same time or about the same year of the Ericsson patent, Mr. James R. Maxwell, a mechanical engineer of Cincinnati, Ohio, designed an eccentric turning lathe on the same principle, having a compound face plate or sliding frame, so ar-

ranged that the amount of ponderable weight was at all times the same on every side of the axis, independent of the piece being turned. These lathes are used for turning oval picture frames and other like work and are among the most difficult of all machines to "hold still," so much so that in some instances it has been found necessary to build a solid wall of masonry over them, so that the vibration would fall in its plane.

Fig. 1.

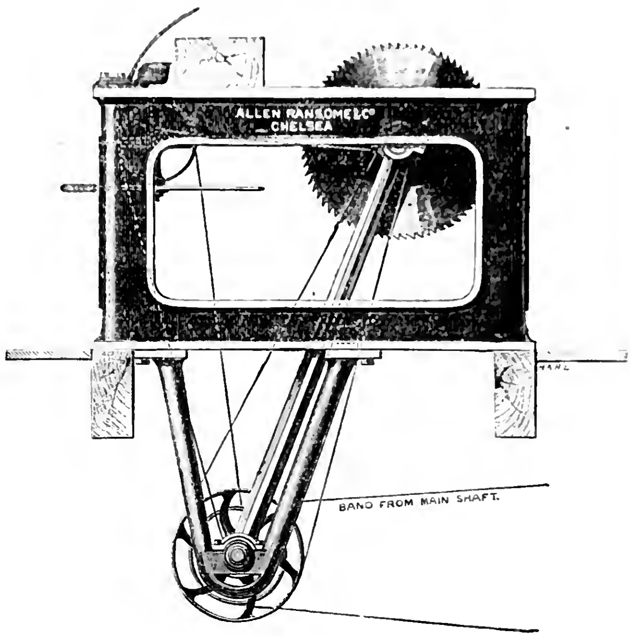


With Mr. Maxwell's improvement these machines are operated on the floor like a saw or molding machine, and cause no jar or vibration that is not absorbed by the counterweight.

It will be quite impossible to consider the question of counter balances in connection with reciprocating motion without diagrams which may be prepared in some future number. The present purpose is to direct attention to it as a thing that has been neglected.

To resume the wood machine notices we present at Fig. 1 in this number a perspective elevation of a surfacing plane invented by B. D. Whitney and manufactured at his works in Winchendon, Massachusetts.

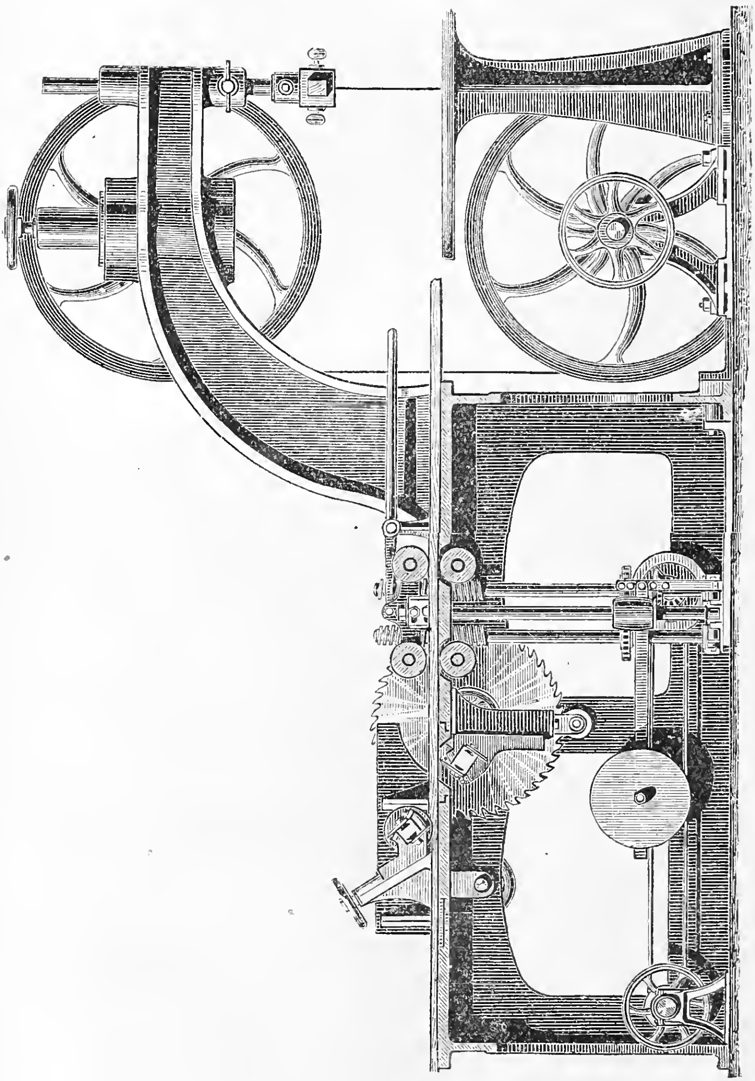
Fig. 2.



The application of fixed cutters in planing machines, as before noticed, is quite old if not the very oldest form in which planers were made; but the idea of a scraping machine with the face of the cutters at right angles with the plane of the lumber is original with Mr. Whitney. While we allude to the face of the cutters in this machine as being at right angles to the surface of the board, the edge is not a continuation of this face; it is, in fact, a scraper similar to that used by wood workmen for smoothing their work only that it is on a more extensive scale, and the operation performed by power instead of by hand. The knives or cutters are thin sheets of steel

which are "set" with a turned edge like a currier's knife before being placed in the machine. The lumber is forced through by a strong arrangement of feed rolls, and is gauged from its bottom surface which is the side acted upon by the cutters.

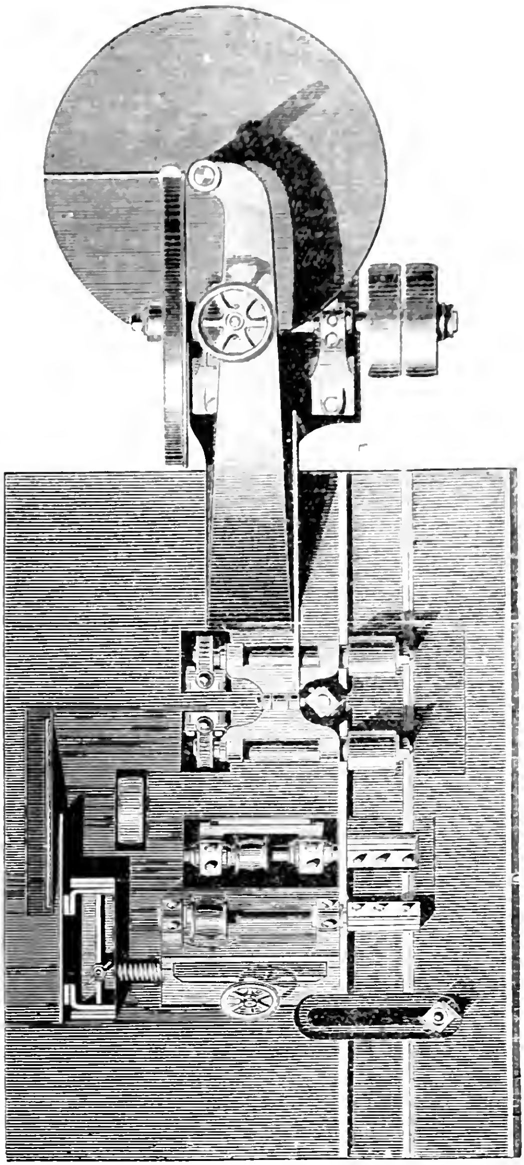
Fig. 3.



This machine, so far as there is any information at command, is a purely American invention; no application of power to scraping

wood on the principle here employed seem to have been made by manufacturers of wood machines in other countries; in fact, the machine would meet with opposition if introduced into many parts of the old world. It takes the place of a kind of hand skill that has not been reached by other machines, that of smoothing up stuff after it has been planed on the common planer, and would no doubt be regarded as taking "the bread from the mechanic's mouth," a cry that has not yet died out even in England.

Fig. 1.



Chair stuff, furniture stuff and even veneered lumber is brought to a perfectly smooth surface and from the undulations left by rotary cutters when passed through these machines. This machine was exhibited at Paris in 1867, and was awarded a silver medal in the great exposition.

Fig. 2 is a side elevation of a cross cutting saw from the de-

signs of Allen Ransome & Co., London, England. It is what would in America be termed an inverted "swing saw," the pivotal joint being beneath instead of above the machine as they are generally arranged in our shops.

This modification of the machine as shown is adapted to shops where the line shafting is beneath the mill floor, a plan that is often met with in England, but rarely in this country except when heavy machines are used.

The operation of the saw is different in the two cases, the axis of the saw being, in the machine illustrated below the lumber, while in the pendulum or overhead saw, it is above; in the one case the eye or centre of the saw is on the gauge side of the stuff, and the wood passes near to the collars; in the other, the eye of the saw is on the varying side of the lumber, and the cutting done on the periphery of the plate—differences which leave great advantages with the machine illustrated; for should the lumber be too thick to be cut through at one operation it can be turned over and severed at two cuts, while in the other case it would not pass beneath the saw mandril unless there was an adjustable table to carry it.

Fig. 3 is a side elevation from a heavy compound machine manufactured by Messrs. A. Ransome & Co., for sawing, planing and molding. The drawing is a true elevation to a scale of $\frac{1}{24}$th, and shows the arrangement of the machine, together with the plan at Fig. 4, so perfectly that no special explanation is needed to make it understood.

There are top and bottom cutters, and side cutters on the molding side, a circular saw on the opposite side with a band saw for curved lines.

(To be continued.)

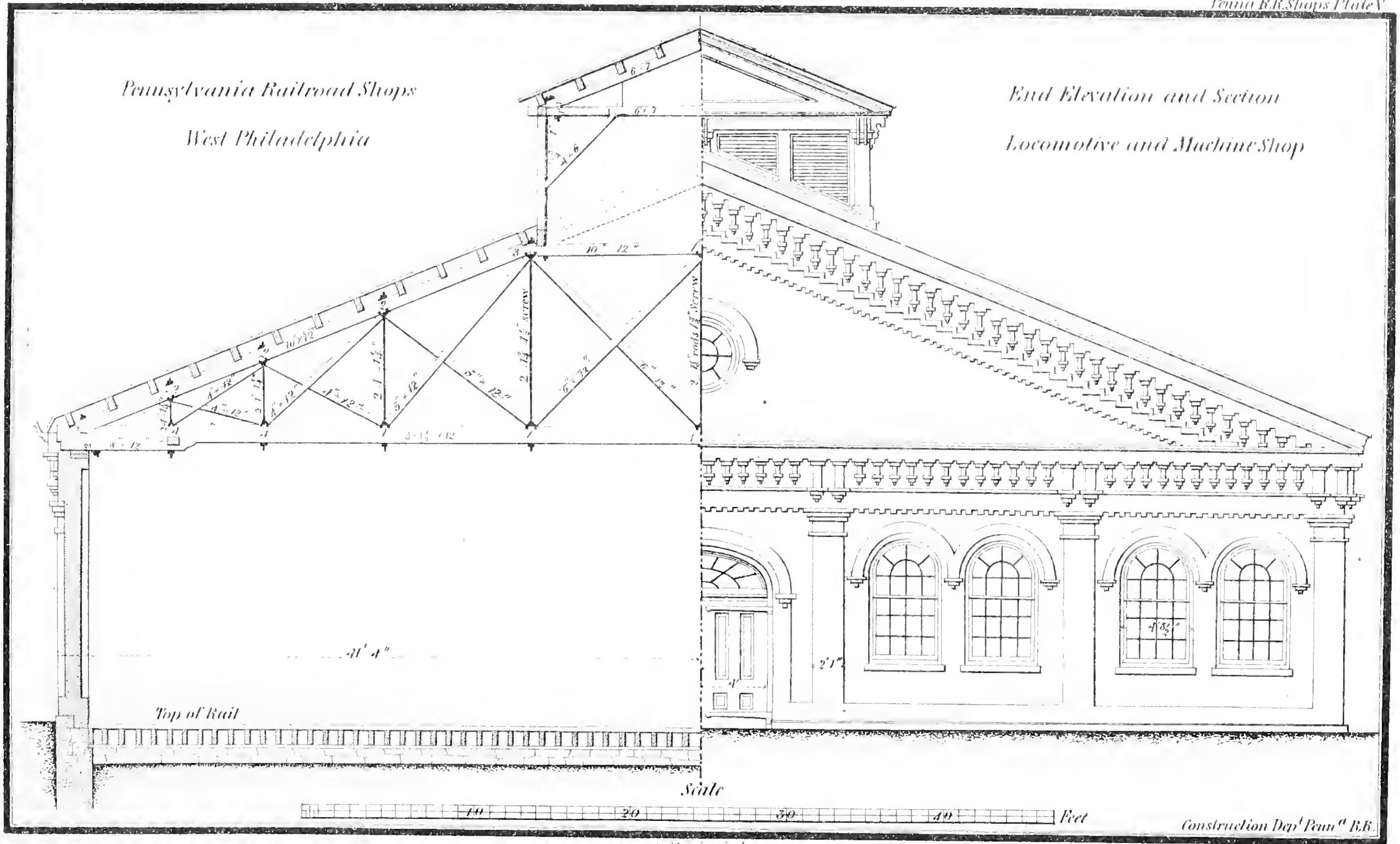
THE PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

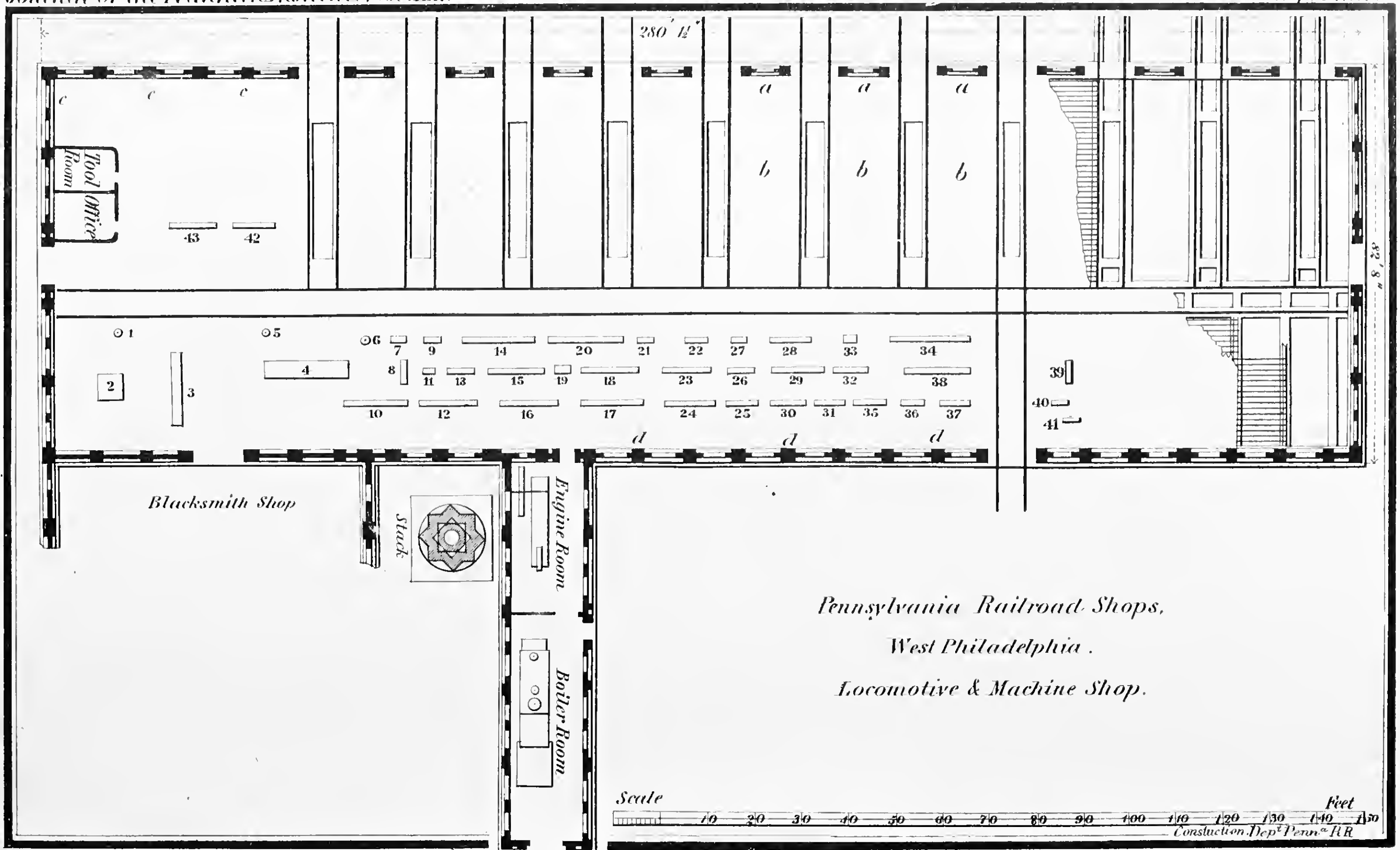
By Joseph M. Wilson, C. E.

[P. A. Engineer, Construction Department, Pennsylvania Railroad.]

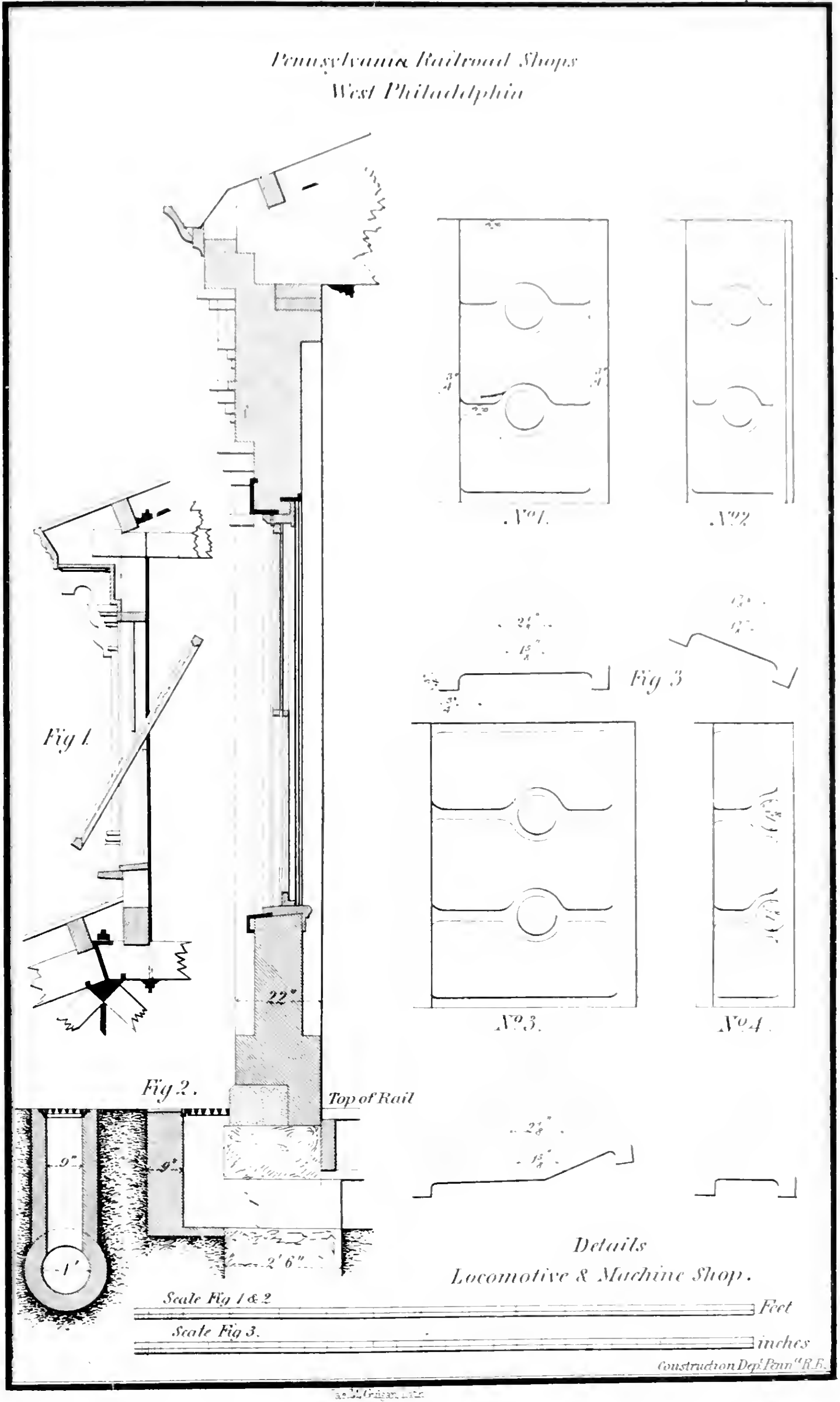
(Continued from p. 317, Vol. LX.)

Locomotive and Machine Shop.—This building, numbered 2 on Plate I, is a rectangle in form, being 280 feet $1\frac{1}{2}$ inches long by 82 feet 8 inches wide, outside dimensions of brick wall, and furnishing a floor area of 21,840 square feet. Plate IV is a plane showing the arrangement of tracks, positions of doors, windows, machinery, &c. Plate V shows an end elevation and section. Plate VI gives de-


Pennsylvania Railroad Shops
West Philadelphia
End Elevation and Section
Locomotive and Machine Shop
Top of Rail
Scale
10
20
30
40
Feet
Construction Dep't Penn'a R.R.
Jas. McGuigan Lith



Jas. M'Guigan, Lith.


Pennsylvania Railroad Shops
West Philadelphia
Fig 1.
Fig 2.
Fig 3
No 1.
No 2.
No 3.
No 4.
22"
9"
9"
1'
2' 6"
Top of Rail
Details
Locomotive & Machine Shop.
Scale Fig 1 & 2
Feet
Scale Fig 3.
inches
Construction Dept. Penn. R.R.

tails. Plate VII is a section through engine and boiler room; and Plate VIII gives elevation, section and details of stack.

There are tracks for eleven locomotives, each provided with a pit. The details of construction of the walls of the building, and also of the pits, are the same as in the locomotive house. The outer foundation walls are 2 feet 6 inches thick, and all inner walls 2 feet. The outer wall finishes off 4 inches below the surface of the ground, and has a belting course on top of cut stone, 9 inches by 15 inches section. All of the doors have cut stone sills 12 inches deep, and where the tracks run through, the rails are cut into the stone, as in the locomotive house, so as to give a flush surface on top. Above the belting course the walls are of brick, built in panels, with pilasters inside and out, and ornamental cornice outside, as shown in plates. Air passages are built in the foundation walls at frequent intervals, to allow of ventilation under the flooring. These are built up to the surface of ground on outside, and are covered with a cast iron grate, flush with the ground line. Fig. 2, Plate VI, shows details of wall with this ventilating passage, and also gives a section through the sewer, showing arrangement for surface drainage. The area between the front of the building and the transfer table is paved with brick. Sewers extend all around the building, and surface drainage is provided between the tracks, and at all necessary points. The pits and the roofs also drain into the sewers. The large doors at the entrance tracks are 11 feet by 15 feet 10½ inches clear opening, and have elliptical heads, the distance from floor to springing line of arch being 12 feet, and the rise of arch to crown 3 feet 10½ inches. These doors are made in two thicknesses of 1¾ inches each, the central portion being glazed. Some of these doors have wickets and some are without. Those with wickets are glazed 2 lights high by 4 lights wide, 13-inch by 20-inch glass, and those without wickets 4 lights high by 4 lights wide, of same size glass. The upper elliptical segments and the lower portions of the doors are paneled and moulded on the outside, and sheeted diagonally on back with tongued, grooved and beaded stuff. These doors all open out, and are hung on heavy cast iron hinge blocks, built into the brick work, three wrought hinges to each door, and they are provided with the same furniture as those in the locomotive house.

In each gable end of the building is an elliptical headed door opening, 8 feet wide, 8 feet 8 inches in height from floor to springing

line, and 2 feet 6 inches rise of arch from springing line to crown. The doors are square at the top, being provided with transome and 5-inch impost, and are 2 inches thick, paneled and moulded on front, and sheeted diagonally on back with narrow 1-inch tongued, grooved and beaded boards. They are hung on cast iron hinge blocks, two wrought iron hinges to each door. The outside door to boiler room is in one piece, and raises vertically, being hung by chains and weights on pullies.

The windows in gable ends of the building are semi-circular headed. Those in the sides are square headed. All have box frames, and cast iron outside sills, and the square headed windows have cast iron outside lintels and inside lintel plates. The sash are in two flights, of 12 lights each, 12-inch by 15-inch glass, and are double hung with cord, weights and axle pullies. In each gable end is a circular window, 4 feet 6 inches, opening in brickwork, with one sash, made to swing in centre of height. The floor joist are 3-inch by 12-inch, white pine, laid 1 foot apart, centre to centre. The wall plates and track stringers are of white oak. The flooring is double, and the details in regard to this, the arrangement of track stringers, and the finish around pits are all the same as previously described in the case of the locomotive house.

The wall plates on top of brick wall are of white oak, in two thicknesses of 3 by 12 inches each, laid to break joint and well pinned together. Plate V shows the construction of the roof truss. The principals are placed 10 feet 6 inches from centre to centre. The principal rafter is of one piece, 10 by 12 inches section, and the tie beam of three pieces, $3\frac{1}{2}$ by 12 inches each, securely framed together with keys, clamps and combination bolts. The number and sizes of the vertical rods are given on the Plate, and the notation reads thus, for instance: 2 rods $1\frac{1}{4}$ inch diameter each, with $1\frac{1}{2}$ inch screw at each end. The ends of the rod are upset, so that the effective section of screw shall be the same as that of the rod. The sizes of the braces are also given on the Plate. Where the braces cross, one is cut, the parts being kept in proper position by dowel pins. The angle blocks are of cast iron, of the forms and dimensions shown, Fig. 3, Plate VI. The blocks are numbered, and the numbers, as marked on the elevation of roof, show their several positions in the truss. Tubes are provided for the rods where they pass through the timber, to prevent the compression of the wood. The purlins are $4\frac{1}{2}$ by 8 inches section, placed 3 feet apart and securely spiked to the principals, at intervals, by $\frac{5}{8}$-inch wrought

spikes. The ventilator, the details of which are shown on Plate V and Fig. 1, Plate VI, runs to within one panel of each gable end of the building. The sides of the ventilator have glazed sash, hung to swing on centre, as shown. By a simple arrangement the sash are so connected together in sets, that by means of a rope they may be readily opened and shut from the floor below, quite a number of sash at one time. The roof sheeting is of white pine 1-inch boards, brought to a surface and worked. The slate is of the best quality, from the Lehigh quarries of Pennsylvania, and of size 10 by 20 inches, laid to weather 8½ inches.

The gutters, valleys and eave pipes are of copper, gauge No. 24. The eave pipes run down into the sewers, and are protected by a cast iron guard near the ground. The building is warmed by cast iron stoves, chimneys being built into the side walls at intervals.

The following is a list of the machinery in the building, numbered to correspond with the plan, Plate IV:

No. 1. Crane. Capacity, 2 tons.
" 2. Wheel Boring Machine. Wm. Sellers & Co., makers.
" 3. Hydraulic Wheel Press. " " " "
" 4. Wheel Lathe. " " " "
" 5. Crane. Capacity, 5 tons.
" 6. Drill Press. Centre of spindle to post, 12 inches; vertical movement of table, 18 inches; hand feeding. Bement & Dougherty, makers.
" 7. Drill Press. Centre of spindle to post, 18 inches; vertical movement of table, 34 inches; hand feeding. Wm. Sellers & Co., makers.
" 8. Grindstone.
" 9. Slotting Machine. From tool to upright, 22 inches; length of stroke, 15 inches; feed motion; circular and horizontal. William Sellers & Co., makers.
" 10. Slide Lathe. Length of shears, 10 feet 3 inches; swing, 20 inches; back geared; screw cutting. Bement & Dougherty, makers.
" 11. Nut Facing Machine. Bement & Dougherty, makers.
" 12. Shaping Machine. Length of shears, 13 feet 1 inch; length of stroke, 12½ inches; double head; feed motion; horizontal, vertical and circular. Wm. Sellers & Co., makers.
" 13. Set Screw Machine. Bement & Dougherty, makers.
" 14. Slide Lathe. Length of shears, 14 feet 10 inches; swing, 30 inches; back geared; screw cutting. Wm. Sellers & Co., makers.
" 15. Slide Lathe. Length of shears, 12 feet 6 inches; swing, 25½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.
" 16. Slide Lathe. Length of shears, 14 feet 3 inches; swing, 25½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.
" 17. Slide Lathe. Length of shears, 12 feet 6 inches; swing, 20½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.
" 18. Slide Lathe. Length of shears, 12 feet 6 inches; swing, 20½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.

No. 19. Shaping Machine. Length of shears, 44 inches; length of stroke, 9 inches; single head; feed motion; horizontal, vertical and circular. Wm. Sellers & Co., makers.

" 20. Slide Lathe. Length of shears, 16 feet 10 inches; swing, 44 inches; back geared. Bancroft & Sellers, makers

" 21. Cotter Drill. Centre of spindle to frame, 15 inches; movement of head, 30 inches; vertical movement of table, 18 inches; self-feeding. Wm. Sellers & Co., makers.

" 22. Drill Press. Centre of spindle to post, 20 inches; vertical movement of table, 18 inches; self-feeding and geared. Bement & Dougherty, makers.

" 23. Slide Lathe. Length of shears, 13 feet; swing, 20 inches; back geared; screw cutting. Bement & Dougherty, makers.

" 24. Slide Lathe. Length of shears, 10 feet; swing, $20\frac{1}{2}$ inches; back geared; screw cutting. Wm. Sellers & Co., makers.

" 25. Slide Lathe. Length of shears, 8 feet; swing, $16\frac{1}{2}$ inches; back geared; screw cutting. Wm. Sellers & Co., makers.

" 26. Slide Lathe. Length of shears, 8 feet; swing, $16\frac{1}{2}$ inches; back geared; screw cutting. Wm. Sellers & Co , makers.

" 27. Slotting Machine. From tool to upright, 14 inches; length of stroke, 10 inches; feed motion; circular and horizontal. Wm. Sellers & Co. makers.

" 28. Horizontal Drill and Boring Mill combined. Table, 48 inches by 23 inches, with 18-inch vertical movement; movement of spindle, 24 inches; double rest, self-feeding. Wm. Sellers & Co., makers.

" 29. Hand Lathe. Length of shears, 12 feet 4 inches; swing, $16\frac{1}{2}$ inches. Wm. Sellers & Co., makers.

" 30. Slide Lathe. Length of shears, 7 feet 10 inches; swing, $12\frac{1}{2}$ inches; back geared; screw cutting. Wm. Sellers & Co., makers.

" 31. Slide Lathe. Length of shears, 7 feet 10 inches; swing, $12\frac{1}{2}$ inches; back geared: screw cutting. Wm. Sellers & Co., makers.

" 32. Planing Machine. Length of shears, 4 feet 7 inches; length of carriage, 3 feet 10 inches; width of post, 19 inches; height of post, 18 inches. Wm. Sellers & Co., makers.

" 33. Drill Press. Centre of spindle to post, 18 inches; vertical movement of table, 34 inches; hand feeding; Wm. Sellers & Co., makers.

" 34. Planing Machine. Length of shears, 22 feet 4 inches; length of carriage, 14 feet 7 inches; width of post, 36 inches; height of post, 36 inches. Wm. Sellers & Co., makers.

" 35. Hand Lathe. Length of shears, 5 feet; swing, 14 inches. Fox Patent.

" 36. Planing Machine. Length of shears, 6 feet 6 inches; length of carriage, 5 feet 4 inches; width of post, 19 inches; height of post, 18 inches; Wm. Sellers & Co., makers.

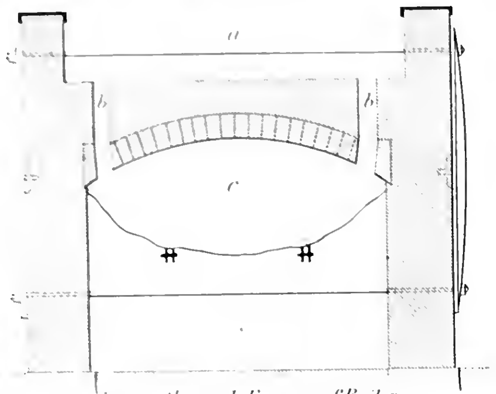
" 37. Planing Machine. Dimensions same as No. 36. Wm. Sellers & Co., makers.

" 38. Planing Machine. Length of shears, 15 feet 8 inches; length of carriage, 10 feet 6 inches; width of post, 25 inches; height of post, 24 inches. Wm. Sellers & Co., makers.

" 39. Drill Press. Centre of spindle to post, $22\frac{1}{2}$ inches; vertical movement of table, 24 inches; self-feeding and geared. Wm. Sellers & Co., makers.

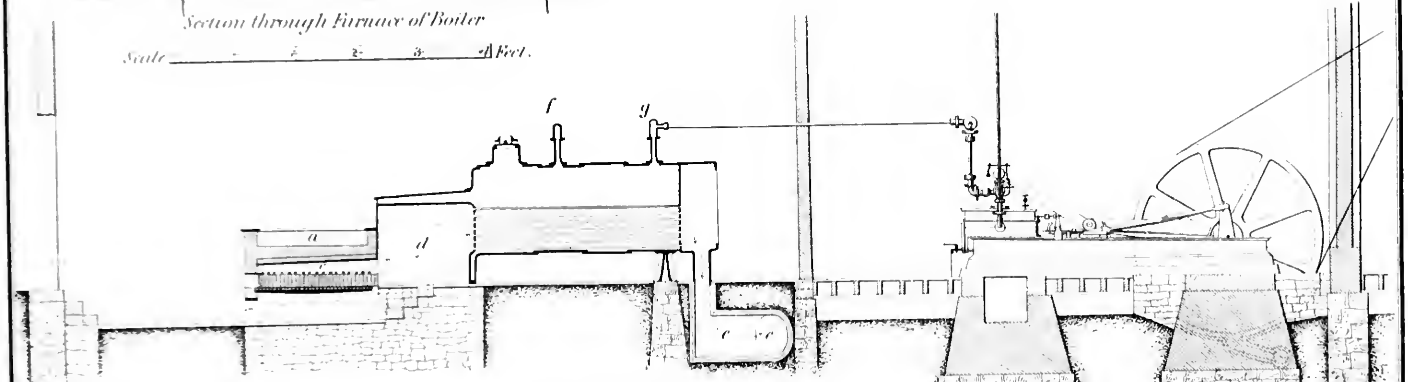
" 40. Grindstone.

Pennsylvania Railroad Shops
West Philadelphia.
Locomotive & Machine Shop.



Section through Furnace of Boiler

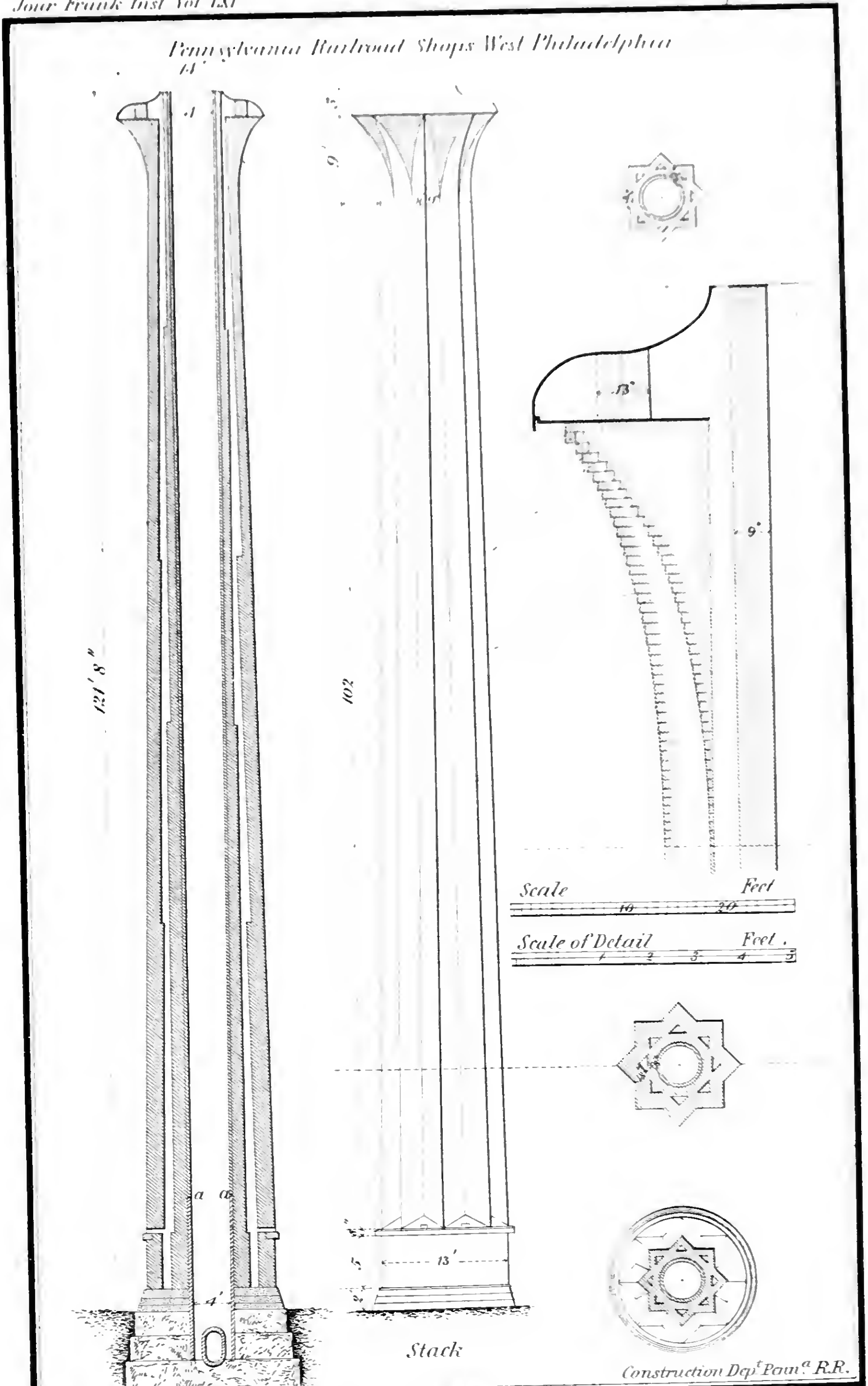
Scale 1 2 3 4 Feet.



Section through Boiler & Engine Rooms.

Scale 10 20 30 Feet.

Construction Dep.t Penn.a R.R.


Pennsylvania Railroad Shops West Philadelphia
14'
121' 8"
102
9' 3"
13"
9"
Scale
Feet
10
20
Scale of Detail
Feet
1
2
3
4
5
13'
4'
a
a
Stack
Construction Dep.t Penn.a R.R.

Jas. M. ... Lith.

No. 41. Two Screw Cutting Machines. Wm Sellers & Co., makers.

" 42. Slide Lathe. Length of shears, 9 feet; swing, 16 inches, back geared screw cutting. Bement & Dougherty, makers.

" 43. Slide Lathe. Length of shears, 10 feet; swing, 20½ inches back geared screw cutting. Bement & Dougherty, makers.

" 44 Drill Press. Overhead For drilling tires; hand feeding. Bement & Dougherty, makers.

" 45. Milling Machine. Length of carriage, 12 inches; raise of cutter, 4 inches; index plate and centres attached. Wm Sellers & Co., makers.

Nos. 44 and 45 have been accidentally omitted on the Plate. No. 44 is located between No. 42 and the track running lengthwise in the building. No. 45 is between No. 1 and the gable end wall.

It is intended occupying the space beyond No. 41 with some new machinery not yet purchased.

Between the tracks, as at *b*, *b*, &c., and along the walls at *a*, *a*, *d*, *d*, *c*, *c*, &c., are located work benches. Each bench has a drawer and closet attached, both being furnished with lock and key, numbered to correspond with a number on the closet. Each workman, therefore, has his own bench, with a closet in which to keep his hat, coat, over-hauls, &c., and a drawer for his tools, all under his own control.

Plate VII shows a section through the engine and boiler rooms. The engine was rebuilt from an old one constructed by Samuel V. Merrick & Sons, some years ago, and in use by the Company before the building of this shop. It is about 90 horse power, diameter of cylinder 16 inches, length of stroke 40 inches, and is provided with a Huntoon governor, but otherwise does not merit attention. The diameter of band wheel is 12 feet.

The boiler was built at Altoona, Penn., R. R. shops. It is of ⅜-inch boiler plate, of the form known as locomotive boiler. What was originally the fire box is now used as a combustion chamber, a self-feeding furnace of brick, lined with fire brick, being built in front as shown on Plate. The fuel used is fine refuse of anthracite coal, and is piled up over the furnace in the part, *a*, from which it feeds down through a series of small square section openings, *b*, *b*, arranged 4½ inches apart, the whole length of the furnace. The fireman, in poking the fire, by running his poker along under the openings, back and forth, can easily regulate the admission of fuel as needed. The boiler is provided with a pair of Richardson's safety valves, a gauge of the Cleveland Gauge Company, registering to 200 pounds, and is fed by an injector.

At *f* a steam pipe goes off to blacksmith shop, to supply steam to hammers. At *g* a steam pipe connects with the engine. The

smoke box of boiler connects, by a passage, *e*, *e*, with the stack. (See Plate VIII.) In this passage, where it runs under the wall of the building, is a slide valve, raised and lowered by means of a winch and chain, to regulate the draft. It usually requires to be kept open about 10 inches. The arrangement of furnace appears to work very satisfactorily.

The stack is of brick, with a cut stone base and cast iron cap, and has a total height of 121 feet 8 inches, the inner diameter of flue being 4 feet. The section is an eight-pointed star, the points of the star being built hollow, with openings to the outer air at bottom and top. There is an inner lining of one brick thick, $4\frac{1}{2}$ inches, not bonded in with the rest of the work, which, as far up as *a*, *a*, is of fire brick, but above that, of ordinary hard brick. The cap is cast in sections and bolted together.

[NOTE.—There are several important improvements we could suggest in this building, especially in the construction of the roof truss, which is faulty in several respects, but as we propose at the conclusion of these articles giving a general review, and taking up questions of this kind, we will not, therefore, consider them here.]

(To be continued.)

THE FAIRLIE ENGINE.

[We have received from the author a copy of a letter on the Fairlie Engine, the accompanying abstract of which we are sure will greatly interest most of our readers.—EDS.]

To the Editor of Engineering:

For the past four years I have noticed in the columns of your valuable paper, and in other papers, long articles on what is called the "Fairlie Engine." I have received pamphlets and accounts of trials of the "Fairlie Engine," and I have seen evidence enough to prove, as far as mere statements can prove a thing, that this so-called Fairlie Engine is a big wonder, and that its merits, if it has any, are being pushed by a man of energy and activity, who has by this time probably brought it to as near perfection as it is capable of being brought. Having for years been deeply interested in Mountain Railways, where steep gradients and numerous sharp curves became a necessity in climbing to summits of great elevation, I naturally studied all the mechanical contrivances and inventions applied to locomotives to overcome these difficulties. It became a necessity, long years ago, in the railway practice of the United States, to have locomotives and cars also that would traverse sharp curves, and steep gradients on mountain sides, during

the storms and frosts of winter, when all [illegible] of track were held as in a giant's vice and irreparable, also during the spring, when this giant's grip was loosened, and mud took the place of adamantine hardness; and to do this with speed and safety, that was the problem to be solved, and it was solved by the adoption of a swiveling truck under the forward part of the locomotive, which was called a Bogie, after a two-wheeled vehicle of that name used in the streets of Newcastle, in England. This was done at the recommendation of George Stephenson, he having proposed it to Robert L. Stephens, of the U. S., in 1832. After listening to the difficulties we must face in adopting railways in this country, I received this information as to the origin of the name, and the first introduction of the Bogie in railway practice, from Mr. Robert Stephenson, in London, 1833. I cannot here refrain from expressing my belief that had George Stephenson lived a few years longer, with the influence, and wonderful mechanical instinct, that rare gift which he possessed in such abundance, the great merits of the Bogie system would have been acknowledged and adopted throughout the whole United Kingdom, as well as in the United States. And it may possibly have been the case that one or more of your readers would have opened their eyes to the fact that England owed a Dukedom to George Stephenson more than she ever owed it to any other mortal. The Bogie was adopted in this country: it had an English origin, but here is its home: here it has been petted, and nursed, and twisted, and turned, and made to do all manner of things, in running around corners of streets and making itself feel at home everywhere, on 50,000 miles of track, good track (if you will allow we have such a thing) and bad track, rough track and smooth track, up hill and down hill, over the mud of spring and the frost of winter, through rain storms and snow storms, over mountains and under mountains, from ocean to ocean, in almost endless forests, over trackless bogs and rolling prairies, where ballast is unknown and unattainable. In the dreary North and the sunny South, there is not a minute in the day or night "when the voice of the Bogie is not heard in the land" (*I mean the meritorious, pecuniary, dividend-making, rail-saving "voice"*), as it carries above it the eagle eye of the engine driver and the life of the sleeping passenger, as thousands on thousands of them are whirled through space in safety, as far as the Bogie is responsible. We claim the Bogie as ours; we love it, place our faith in it, and defy any other people to make it do more for them than it has done for us. When Mr. Fairlie took up the long exploded idea of a double Bogie Engine to work sharp curves and climb mountain gradients, he jumped out of a groove, in which he had seen only the stereotyped model engines which your paper in October, 1868, very wittily termed a six-footed beast. He did not know that such engines on our roads would ruin us in a year; he did not know what wonders we had made the Bogie perform in its dress of late

years, of radial bars, swing-links, and equalizing levers fore and aft, and cross-ways; and what is more, he did not, would not, and could not see it when he came here. Although it was shown to him, by the most extensive engine builder in this country, he insisted that what he saw was not so. If Mr. Fairlie had seen things as they were, and not as he wished them to be; if he had possessed a portion of the mechanical instinct that made George Stephenson's name a pride throughont the engineering world, he would have returned to England (as an English engineer said to me a short time since) a wiser man, for he could have seen on many railways in the U. S. that American Engineers have done with the single Bogie, and its various mechanical appliances, more than he has ever done, or ever can do, with his double Bogie engine; he could have saved himself much trouble, waste of precious time, and anxiety of mind, over an invention which is condemned by the leading locomotive engineers of the world, and particularly the engineers of England, and he would probably have saved some railway companies considerable sums of money. Having said so much, and intending to say more, in the way of criticism, and in the face of the opinion of the great *London Times*, and the certificates of Dukes and Counts, that this so-called Fairlie Engine is a wonder, I will add that when Mr. Fairlie can show me on mountain grades and sharp curves as much work done in proportion to weight on drivers, and at the same cost, as I can show done by American Engines, I will become a convert, adopt his system, and give him the entire benefit of it, if he can prove to me that any part of it had its origin in his brain.

Wishing to know the comparative merits of the so-called Fairlie and the American Bogie Engine, I have, thinking that figures put down in all honesty would not lie, taken trials of two of the Fairlie Engines as printed by himself, and vouched for by a Duke, a Count, and other railway experts, and put them by the side of trials of engines built under my direction, and experimented with one in Chile by order of that Government, and one in Peru by order of that Government, both trials being witnessed by English engineers. I send you a copy of this table of comparisons; it speaks for itself. I have brought the whole four trials down, as near as it can be done, to one standard, which you will find at the bottom. It is "foot-pounds" of work done in lifting train alone, exclusive of engine, per hour, per ton of weight on drivers, calculated from weight of train, speed per hour, and elevation overcome.

Memoranda in reference to Engine Comparisons.

1st. In calculating atmospheric resistance I have used the frontage formulæ, not having the cubic feet of bulk in the train, the only proper data from which to calculate the atmospheric resistance; the total amounts, in the cases stated, are not important, as the speed was not great.

2d. The American engines were running on tracks built by Americans, and in the American cheap style; while the Fairlie engines were running on English railway tracks, which are, in England at least, considered to be the best in the world.

3d. The "San Bernardo" was running on a track which was essentially straight, the minimum curvature being 6,562 ft. radius. The "Conquistador" was run on a track full of curves of 350 ft radius, combined with gradients of 3 per cent. (151 ft. per mile), and encountering long gradients of 4 per cent. (211 ft per mile), combined with curves of greater radius. The data for comparison was taken while running on the 4 per cent. gradients, with poor fuel and bad water. This, in a measure, accounts for the wide difference between the performance of the two American engines, for D. K. Clark, in his work on Locomotives, says, page 267: "It was estimated that a curvey line, having one curve under one mile radius for every two and a half miles, incurred an excess of resistance equal to 20 per cent. of that due to a line practically straight."

4th. In the table, the Fairlie engine, "Progress," is taken at 54 tons. Colburn told me he weighed this engine, and found it to weigh over 60 tons.

5th. The only fair and perfectly reliable way to test engine performances, is to get them on the same track, under the same conditions. But in the above table of comparisons the differences are so enormous that it is easy to tell where the greatest merit lies.

6th. Engine frictions vary greatly, but for the above calculations 10 lbs. per ton is taken as a fair average for all. Fairlie calls the frictions of his engines 18 lbs. per ton.

7th. There is no allowance made in the table for adhesion, being less on the steep gradients than on ordinary easy gradients.

8th. The American engines in both trials showed their ability to make all the steam required on the maximim gradients, in fact the fire door of the "San Bernardo" had to be kept open most of the time to keep her steam down to 115 pounds, the limit agreed on; the Fairlie engines failed to make the steam required.

9th. The Fairlie engine, "Progress," could not start her train of 472 tons on a gradient of 1 in 90 with 150 pounds of steam; the "San Bernardo," with less than one-third of the weight on drivers, started a train of 559 gross tons, and one brake screwed down, on a grade of 1 in 400, with 118 pounds of steam.

10th. Fairlie's data for calculations is not complete. The most favorable in his pamphlet for the "Progress" is that she was running with 476 tons at 8 miles per hour, with 140 pounds of steam, up a gradient of 1 in 90.

W. W. EVANS.

New York, Sept. 11, 1870.

TABLE OF COMPARISONS OF FAIRLIE AND AMERICAN ENGINES.

No.		FAIRLIE ENGINES.		AMERICAN ENGINES.	
		Little Wonder.	Progress.	San Bernardo.	Conquistador.
1	Name of Railway	Festiniog, Wales.	Mid. Wales.	Southern, of Chili.	Arequipa, of Peru.
2	Gauge of Railway	1′ 11½″	4′ 8½″	5′ 6″	4′ 8½″
3	Weight of Engine, loaded, in gross tons	19·50	54·	28·11	34·21
4	" " " " " on drivers	19·50	54·	17·48	25·89
5	" " " on each driving wheel, in gross tons	2·44	6·75	4 37	4·31
6	Number of Driving Wheels	8·	8·	4·	6·
7	Number of Wheels under each Engine	8	8	8	10
8	Length of Wheel Base	19′	22′·	22′	22′ 7½″
9	Diameter of Driving Wheels, in inches	28″	54″	56½″	49″
10	Number of Cylinders	4	4	2	2
11	Dimensions of Cylinders, in inches	$8\frac{3}{16}'' \times 13''$	$15'' \times 22''$	$16'' \times 24''$	$18'' \times 24''$
12	Average Pressure of Steam in Boilers during trials, in pounds	175·	140·	115·	130·
13	Adhesion at 20 per cent. of weight on driving wheels, in pounds	8 733	24 192	7,831	11,599
14	Adhesion at 30 per cent. of weight on driving wheels, in pounds	13,101	36,288	11,746	17.398
15	Load hauled, excluding engine, in gross tons	121,875	476·	340 89	138·88
16	Load hauled, including engine, in gross tons	141,375	530·	369·	173·09
17	Gradient overcome—ratio of height to base	1 in 92	1 in 90	1 in 94·3	1 in 25
18	Gradient overcome, in feet, per mile	57·30	58·70	56·	211·20
19	Speed of Trains, in miles, per hour	11·25	8·	17·	10·
20	Reistances of Gravity, in pounds	3442·	13191·	8765·	15508·
21	Resistance of Rolling Friction at 5 lbs. per ton	707·	2350	1845·	865·
22	Resistance of Oscillation and Concussion $\frac{W\ V}{10}$	153·	424·	627·	173·
23	Resistance of Air (by frontage formula), say, area of 100 square feet	31·	16·	72·	25·
24	Resistance of Friction in Engine at 10 lbs. per ton	195·	540·	281·	342·
25	Total Resistances, in lbs	4534·	16821·	11590·	16913.
26	Percentage of Weight on Driving Wheels, utilized	10½·	14·	29½	29·
27	Pounds Traction per Ton of Engine alone	233·	311·	412·	491·
28	Proportional Power per ton, Little Wonder as unity	1·	1·34	1·77	2·12
29	Total foot pounds of work done per hour, calculated from resistances	269 319,600	710,519,040	1,040,318,400	893,003,400
30	Total foot pounds of work done per hour per ton of weight on drivers calculated from resistances	13,811,261	13,157,760	59,514,782	34 492,329
31	Total foot pounds of work done per hour (calculated from weight of Train and elevation overcome	204 139 614	557,509,120	786,885,120	818,867,840
32	Foot pounds of work done per hour per ton of weight on drivers (from weight of train and elevation overcome)	10,468,699	10,321,242	45,016,311	31,624 868
33	Foot pounds of work done per hour in lifting train, exclusive of engine (from weight of train and elevation overcome)	175,982,419	500,706,304	726,941,107	657,024,614
34	Foot pounds of work done per hour per ton of weight on drivers, in lifting train alone, exclusive of engine (calculated from weight of train, speed per hour, and elevation overcome per mile)	9,024 729	9 272 339	41,587,021	25,377,544

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 22.)

Page's Patent Tanned Leather Belting. This excellent belting leather is made by Page Brothers, in Franklin, N. H. It possesses greater pliability, strength and durability than the ordinary tannage, will endure moisture better, is lighter, adheres to glue and cement as well as any belting, and, being softer, will answer better for round belts. It has been thoroughly and successfully tried, and costs no more than well made oak-tanned belting.

A trial showed twenty-five per cent. more adhesive power than hard oak or hemlock tanned leathers, and a test of strength proved that, while 1050 pounds broke an $1\frac{1}{4}$-inch wide oak-tanned belt, it required 1850 pounds to break the same size Page belt.

The single belts are $\frac{1}{4}$-inch, the light double belts $\frac{5}{16}$-inch, and the heavy double $\frac{3}{8}$-inch thick.

The light double belts, which are about the same price as best single, work well on cone and flange pulleys, and, of course, very well where running free and where much shifted.

The adhesive power of this belting is so great that the single belts will not do well on cone or flanged pulleys, but run up the flange and turn over.

Mr. A. K. Rider, of De Lamatre Iron Works, N. Y., has favored me with the following:—"Our rule, which appears to work well and gives very satisfactory results, is based on the assumption that a belt one inch wide, when properly surfaced and sufficiently tight, and bearing on not less than one-third the circumference of smaller pulley, will transmit a force of $19\frac{1}{4}$ pounds *at any velocity.* The power of a belt, in foot pounds, is thus readily obtained by multiplying its velocity in feet per minute by its width in inches, and again by $19\frac{1}{4}$. The generally received rule is, 144 square feet of surface passing per minute equals one H. P., and the cohesive strength of good belting is taken at 4000 pounds per square inch of section as its breaking strength."

Friction of Belts.—"The friction of belts upon pulleys depends upon the extent to which they are tightened, the extent of circumference with which they are in contact, and their breadth. It is commonly believed that the greater the diameter of pulley, the more surely does the belt cause it to revolve without slipping.

Theoretically, however, and we believe practically, it will be found that, with equal degrees of tightness, equal breadth of belt, and equal circumstances as to perfection of contact, the friction of a belt on the circumference of a pulley is the same, whatever be its diameter. The only circumstance that can affect the constancy of the result, is that belts not being perfectly flexible, lie more closely to surfaces curved to a large radius than to those of smaller radius. When a certain amount of power has to be communicated through a belt, the speed at which the belt moves has to be taken into account, because power being pressure multiplied by velocity, the greater the velocity with which the power is transmitted, the less the pressure that has to be communicated at that speed, In this sense, then, it appears that the larger the pulley the less is the slip of the belt, because the greater the circumference of the pulley, revolving at a given angular velocity, the greater is its absolute velocity through space, and therefore the less the pressure required to communicate a given power.

"It is found, practically, that a leather belt 8 inches wide, embracing half the circumference of a smoothly-turned iron pulley, and traveling at the rate of 100 feet per minute, can communicate one horse-power.

"When less than half the circumference of the pulley is embraced, the strap must be proportionally wider; and when more than half the circumference is embraced, its width may be less.

"The law according to which the friction of a belt increases with an increased arc of contact, is of a peculiar character; but may be readily understood by comparing the friction on arcs of different lengths. If a pulley (of any diameter whatever) were prevented from revolving, and a belt passing over part of its circumference were stretched by a certain weight at each end, additions might be made to the weight at one end until the belt began to slip over the pulley. The ratio which the weight so increased might bear to the weight at the other end, would measure the amount of friction.

"For example, in experiments made to test a theoretical investigation on this subject, a belt passing over a pulley in contact with 60° of its circumference, was stretched by a weight of 10 pounds at each end. One of the weights was increased until it amounted to 16 pounds, when the belt began to slip. The ratio of 16 to 10, or $\frac{16}{10} = 1{\cdot}6$ was then the measure of the friction. When 20 pounds at each end were used to stretch the belt, the one weight was increased to 32 pounds, giving the ratio of $\frac{32}{20} = 1{\cdot}6$, the same as be-

fore; and likewise, when 5 pounds were [illegible] weight at one end was increased to 8 pounds, giving [illegible] ratio, $\frac{8}{5}$ = 1·6. So far, then, the friction was pro[illegible] to the stretching weight, as might have been expected from the ordinarily received doctrine on the subject of friction. On extending the arc of contact to 120°, the ratio was found to be 2·56, or $1{\cdot}6^2$ And again, on embracing 180° the ratio was found to be 4·1, or very nearly $1{\cdot}6^3$

"The theoretical investigation brought out this result independently, and the following law may therefore be taken as established:

"If, for any given arc of contact, the one weight bears to the other, at the point of slipping, a certain ratio—for double the arc, the ratio will be squared; for triple the arc, it will be cubed; for four times the arc it will be raised to the fourth power; and so on.

"In all cases, however, much depends on the tightness of the belt, the limits to the force with which it is strained being, first, the tensile strength of the belt itself, and, secondly, the amount of pressure that it may be convenient to throw upon the shaft and its bearings. New belts become extended by use, and it is therefore frequently necessary to shorten them. Before use, they should be strained for some time by weights suspended from them, so as to leave less room for extension while in use. Wherever belts are employed, they should be of the greatest breadth, and travel at the greatest speed consistent with convenience, as it is most important to have the requisite strength in the form best suited to flexure, and the least possible strain on the shafts and bearings.

"When ropes or chains are employed, as in cranes, capstans, windlasses, or the like, for raising heavy weights or resisting great strains, the requisite amount of friction is obtained by coiling them more than once round the barrel of the apparatus. It is found that one complete coil of a rope produces a friction equivalent to nine times the tension on the rope, the barrel being fixed. Two complete coils of the rope produces a friction equivalent to 9 × 9 times the tension, and so on. The diameter of the barrel does not affect the result.

"Having regard to these facts, we may readily understand the force with which a knot on a cord or rope resists the slip of the coils of which it consists, for the several parts of the cord act as small barrels, round which the other parts are coiled; and the yielding nature of the material of which the barrels are composed, permits the coils to become impressed into their substance on the application of force, and prevents them from slipping more effectually than if they were coiled on a hard and resisting barrel."—*From Wylde's Circle of the Sciences. London.*

(To be continued.)

Mechanics, Physics, and Chemistry.

ON AMMONIUM AND THE SOLUBILITY OF METALS WITHOUT CHEMICAL ACTION.

By Chas. A. Seely.

In April and May last it came in my way to make a pretty careful study of the constitution of the so-called ammonium amalgam, and on May 9th, I reported to the Lyceum of Natural History of New York what I had done in the matter up to that time. Subsequently, I continued the study, and was led to the discovery of the solubility of the alkali metals in anhydrous ammonia, an account of which formed a paper read at the Troy meeting of the American Association for the Advancement of Science. Neither of these communications have been printed; the first was oral, and the latter was lost. The present paper is intended to be a concise and authoritative statement of the contents of the two papers and as a substitute for them.

In the Lyceum communication I proved that the so-called ammonium amalgam is in fact no amalgam at all, but a metallic froth of which the liquid part is mercury and the gaseous part a mixture of hydrogen and ammonia. This conception of the nature of the substance was at that time not altogether novel, but the considerations through which the conclusion was reached, were believed to be new and of such moment that taken together they have the effect of a demonstration. The considerations were these:

1st. In the formation of ammonium amalgam the mercury is increased in bulk tenfold or more, while in weight it is increased only one or two thousandths. This fact would be easily predicted by the froth theory while otherwise it is anomolous and utterly inexplicable.

2d. Ammonium amalgam has less of the mirror surface than mercury; it approaches in appearance the whiteness and lack of lustre of mat silver. This fact also finds a satisfactory explanation in the froth theory.

3d. Ammonium amalgam is readily compressible; when confined in a fire syringe it steadily contracts on forcing down the piston till the original bulk of the mercury is almost reached, and on re-

hoving the pressure the original volume and [illegible] re-sumed. It is only a froth which behaves in this manner.

Either (1) or (3) will be conclusive to [illegible] forward as a fair *experimentum crucis*. The [illegible] sure is easy to execute, and an elegant experiment for the lecture room. The condensation is somewhat greater than in the case of atmospheric air for the reason that some of the ammonia [illegible] into the liquid state.

Having concluded that the ammonium amalgam is a mercuric froth, a very important question presents itself: Why and how do metal and gases become mingled? A froth is a mechanical mixture, and in all ordinary cases the manner of mixing and the forces engaged are quite evident. In the formation of the mercuric froth, the mercury covered by a watery solution rises up spontaneously into the comparatively light water, and the still lighter gases descend into the mercury and mingle with it until they become diffused through its whole mass. What are the forces which thus overpower the action of gravity? Moreover, a froth implies a certain viscosity or plasticity of the liquid which seems not to be possessed by the mercury in its normal condition. Do hydrogen and ammonia in their nascent state have the power to modify the physical properties of mercury? The production of mercuric froth as a fact of physics simply may seem anomolous and paradoxical. Is it necessary after all to admit the existence of an ammonium amalgam, not of course as a constituent of the mercuric froth, but as a condition precedent of the formation of the latter,—in other words, of another ammonium amalgam to satisfy a new theory?

I was making satisfactory progress in the investigation of the theory of mercuric froth when, early in May, my attention was diverted to the researches of Weyl on ammonium and compound ammoniums as reported in *Watt's Dictionary* (article, Sodium), and in the last edition of *Fownes' Chemistry*: subsequently, I compared Weyl's original memoirs in *Poggendorff's Annalen* of 1864. Weyl's statements and conclusions were quite at variance with my own views: his alleged facts were inconsistent with my own experience. Weyl, it appeared, had actually isolated ammonium; if he represented the facts correctly all my work needed revision. I therefore at once devoted my whole care to a verification of his results. I repeated his experiments, some of them many times, and with such precautions, modifications and additions as the

case seemed to require. The result of all is that I find that Weyl has had only an imperfect apprehension of the fundamental facts, and that thus building on a weak foundation the superstructure of reasoning and conclusion cannot stand. For the purpose of presenting in a clearer light what I suppose to be of more interest to the chemical world, I dismiss, for the time, the consideration of Weyl's views, and I proceed to give what in my judgment are the proved physical and chemical facts.

This discussion involves the relation of ammonia to the alkali metals, and the results which grow out of that relation. Now, the key to the whole subject is the fact that liquid anhydrous ammonia is a solvent, without definite chemical action, of the alkali metals. I mean that these metals dissolve in the ammonia as salt dissolves in water,—the solid disappears in the liquid, and on evaporating the liquid, the solid reappears in its original form and character. There is no definite atomic action in any such cases; the components of the solution are not changed in their chemical relations to other substances.

I began my experiments by bringing together ammonia and the metals in sealed inverted U-shaped glass tubes. Chloride of silver saturated with ammonia was placed in one leg of the tube, and the metal under test in the other; the chloride of silver leg being immersed in boiling water, and the other in ice-cold water, the ammonia was liberated and passing over was gradually condensed on the metal. Such an arrangement, although sufficient to demonstrate the fact of the solution of the metal, proved inconvenient in several respects; the tube is liable to burst, the experiment can be made only on a pretty small scale, the chloride of silver does not absorb a desirable amount of ammonia, and by reason of its fusing or agglomerating, the rapidity of its absorption varies greatly. I therefore constructed an ammonia generator or retort of iron, to the horizontal neck of which turned downward at its end, I attached by means of an iron screw coupling the stout glass tube containing the metal or other substance to be subjected to the ammonia. In the place of the chloride of silver I substituted anhydrous chloride of calcium saturated at 32° Fahr. with anhydrous ammonia. With this arrangement the experiments were continued with comparative ease and expedition.

When sodium is subjected in this apparatus to the condensing ammonia, before any ammonia is visibly condensed to the liquid

state, it gradually loses its lustre, becomes of a dark hue and increases in bulk. The solid then appears to become pasty, and at last we have only a homogeneous mobile liquid. During the liquefaction, and for a little time after, the mass is of a lustrous, copper-red hue; the condensation of the ammonia and its mingling with the liquid steadily goes on, the liquid is progressively diluted, and passing through a variety of tints by reflected light at last it becomes plainly transparent and of a lively blue as well by reflected as by transmitted light; the liquid now closely resembles a solution of aniline blue or other pure blue dye-stuff. On reversing the process by cooling the ammonia generator, the ammonia gradually evaporates out of the liquid, and the changes observed during the condensation reappear in the reverse order, till at last the sodium is restored to its original bright metallic state. If the evaporation be conducted slowly and quietly the sodium is left in crystals of the forms seen in snow. The formation of the transparent blue liquid, and the restoration of the sodium are steadily progressive, and the repeated and closest scrutiny of the process has failed to reveal the slightest break or irregularity in its continuity. The inevitable conclusion from such facts is that the blue liquid is a simple solution of sodium in ammonia, not at all complicated or modified by any definite chemical action.

If crystallized sodium amalgam be made to replace the sodium in the experiment it remains unchanged although it is probable enough that at a higher temperature or with a larger excess of sodium, some of the sodium would be removed. This interesting fact is consistent with the simple solubility of sodium in ammonia, and indeed is some confirmation of it. The force, whatever it be, which keeps together sodium and mercury is certainly weaker than that exhibited between sodium and ammonia. If sodium amalgam is not a definite chemical compound, then surely the blue liquid cannot be. I have not yet made the experiment to determine whether mercury will remove sodium from its ammoniacal solution, but it seems extremely probable that it would so act.

The brilliant and varied colors exhibited in the experiment may seem anomalous to some, when, in fact, a closer scrutiny of the case will show that they might have been predicted. Sodium appears white to the eye, but with the white light reflected from its surface to the eye, there are always mingled red rays. If most of the incident white light were normally decomposed, sodium would appear

as a brilliant red metal. Ammonia favors such a decomposition probably by reducing the density and opacity of the surface, and thus the concentrated solution of sodium is lustrous copper-red by reflected light. What should be the color by transmitted light? Not red, for the red rays do not penetrate the substance; the color must be looked for in that which is complementary to red; it must be blue or yellow or combinations of these. A continuance of the argument will bring the conclusion that the color by transmitted light will be blue. Intense blue tinctorial substance, like aniline blue, indigo and Prussian blue, all illustrate the phenomena of color of the sodium solution; they are metallic red when concentrated, and if the solvent be applied in vapor as in the sodium dissolving experiment, there will be the same modification of color exhibited. Sodium has a remarkable tinctorial power which seems not to be surpassed by that of any of the aniline colors.*

If a salt of a metal electrically negative to sodium be subjected with the sodium to the ammonia, in the apparatus, the sodium will replace the negative metal, and the latter will be reduced to the simple state. This reduction seems always to be accompanied with the evolution of heat, but does not commence till a visible quantity of the sodium solution is formed. It is possible that there may be exceptions to these generalizations. I need only say that they seem extremely reasonable, and are confirmed by a good many experiments. The reaction furnishes a very simple and elegant process for the reduction of rare metals. I anticipate that the process will prove of great value.

I have heretofore spoken of the solution of sodium only, for the reason that it is a typical case, and because demonstrations can be more satisfactorily made with it. Potassium behaves towards ammonia in almost precisely the same way. It is readily dissolved, the strong solution being copper-red and the diluted solution blue. Lithium gives also a blue solution, but is not nearly so soluble. The only other alkali metal I have tried is rubidium, and although the experiment was prematurely ended, it had progressed far enough to make it almost certain that rubidium is soluble like potassium, and I intend, as soon as I can procure material, to repeat the rubidium experiment.

Besides the metals named, I have subjected many others to the ammonia, and have found none outside of the alkali metals which are in the least affected. I have directly tried aluminium, magnesium, thallium, indium, mercury and copper.

* For a further elucidation of the matter of this paragraph I would refer the reader to my paper on the "Colors of Metals," printed in the proceedings of the Lyceum of Natural History, of New York, of October, 1870.

Chemical Laboratory, 26 Pine Street, N. Y.

A NEW FORM OF SOLAR EYE-PIECE.

By Prof. S. P. Langley.

Of late years, a form of solar eye-piece has been generally used in which a plane reflector of unsilvered glass is placed between the eye-lens and the objective, and at an angle of 45° with the axis of the cone of rays from the latter.

About six per cent. of the light is reflected to the eye, and the remainder transmitted or absorbed by the glass, whose posterior surface is so inclined to the first as to avoid any interference from secondary reflection. The rays thus weakened are further absorbed by a dark glass, which may be of comparatively light tint as compared with that necessary for the direct beam.

More recently it has occurred to many beside the writer, that the introduction of a second reflector would permit a radical improvement, by giving the power to polarize the beam. Solar eye-pieces on this principle, employing as many as four reflections, have been constructed in Munich, and others, with two or more, have been made in this country, by Mr. Tolles, of Boston.

I have not seen any of these instruments, but having been at some pains in the construction of one which cost a good deal of experiment, I hope that this description may be useful to any one who wishes another. The theory of the instrument is too simple to need much explanation.

Since the polarizing angle depends on the refractive index of the glass, for the ray, with sunlight a part of the spectrum, must remain unpolarized, which is greater or less, according to the dispersive power of the medium employed for the reflectors: for these should, of course, be chosen some glass of moderate dispersive power. Let this be plate glass, and let it be assumed that its index or refraction for some ray near the green, or most luminous part of the spectrum, is 1·525. Then, by the use of a familiar formula, we find that the angle of incidence at which this ray will be completely polarized is 56° 45′. The reflectors should then be cut, so that their faces may present a section of the cylinnder, made at an angle of 33° 15′ with the axis. The essential condition to secure, will, however, be that the reflecting surfaces are optically perfect planes, and the successful use of the instrument presupposes the best work in this particular.

The second surface may be plane, and inclined at a suitable angle to the first, or worked (as suggested by Sir John Herschel for a similar purpose) to a concave figure; the secondary reflection being in either case avoided.

When the reflecting planes are parallel, about eight per cent. of the light incident at the angle of maximum polarization is received from the first surface, and eight per cent. of this fraction from a second. With three such planes, about $\frac{1}{2000}$ of the incident light is reflected. It is significant of the intensity of the solar radiation that the light thus diluted two thousand times is still intolerably bright. The beam is supposed here to be still unpolarized, but as the polarization is in any case but partial, it becomes a question how many reflections are necessary, and this can only be decided by trial. In my experience, two are not enough to give the best results, as with the least dispersive material that can be chosen for the prisms, enough light remains after polarization to fatigue the eye. Four are unnecessary, since I find that with three the light may be enfeebled, till the eye finds it difficult to recognize the details of the solar surface.

It remains to describe the manner in which these are used.

If the rays concentrated by a large object-glass fall centrally on the first reflector, it will heat equally, and be in little danger of injury, but if it be placed so that these rays are only on part of it, (which will generally be the case in examining the limb of the sun) a fracture of the glass is not unlikely to result. The actual loss of one in this way led me to the construction finally adopted, which is nearly this: The first reflector is to be larger than the greatest diameter of the solar image in the telescope to which it is applied. It is fixed in position and direction, and the rays from the sun being brought centrally on it, are kept there by the clock-work of the equatorial. The second and third reflectors have a common motion independent of the first, by which they are enabled to receive centrally the rays from any part of it. This is effected by mounting both on a mechanism like the stage plate of large microscopes, while the third reflector has a motion of rotation about the line joining its centre with that of the second.

When the three planes are parallel, the light is enfeebled by reflection only, but when, in addition, the third is turned through an angle of 90° from this position, the light of the sun, even when received from the full aperture of a 13-inch lens, emerges free from

adventitious color, and of scarce sufficient intensity for the ready observation of details. It is, of course, only necessary to turn the prism through more or less than 90° to obtain every gradation of light up to dazzling brightness, and this extreme facility of control is not the least advantage of this form of eye piece.

The instrument I have described may be constructed at less cost, by omitting the independent motion, which has been described as carrying the second and third reflector above the first. These may, if retained, have a graduated index, and readily serve as a sufficiently accurate micrometer for ordinary work on the sun, or they may be wholly discarded. The instrument will be effective without them if sufficient care ensures that the first reflector is not broken by the heat, and in this form is easy of construction, and need be of only moderate cost.

ON THE RECTIFICATION OF PETROLEUM.

By Prof. Edward Parrish.

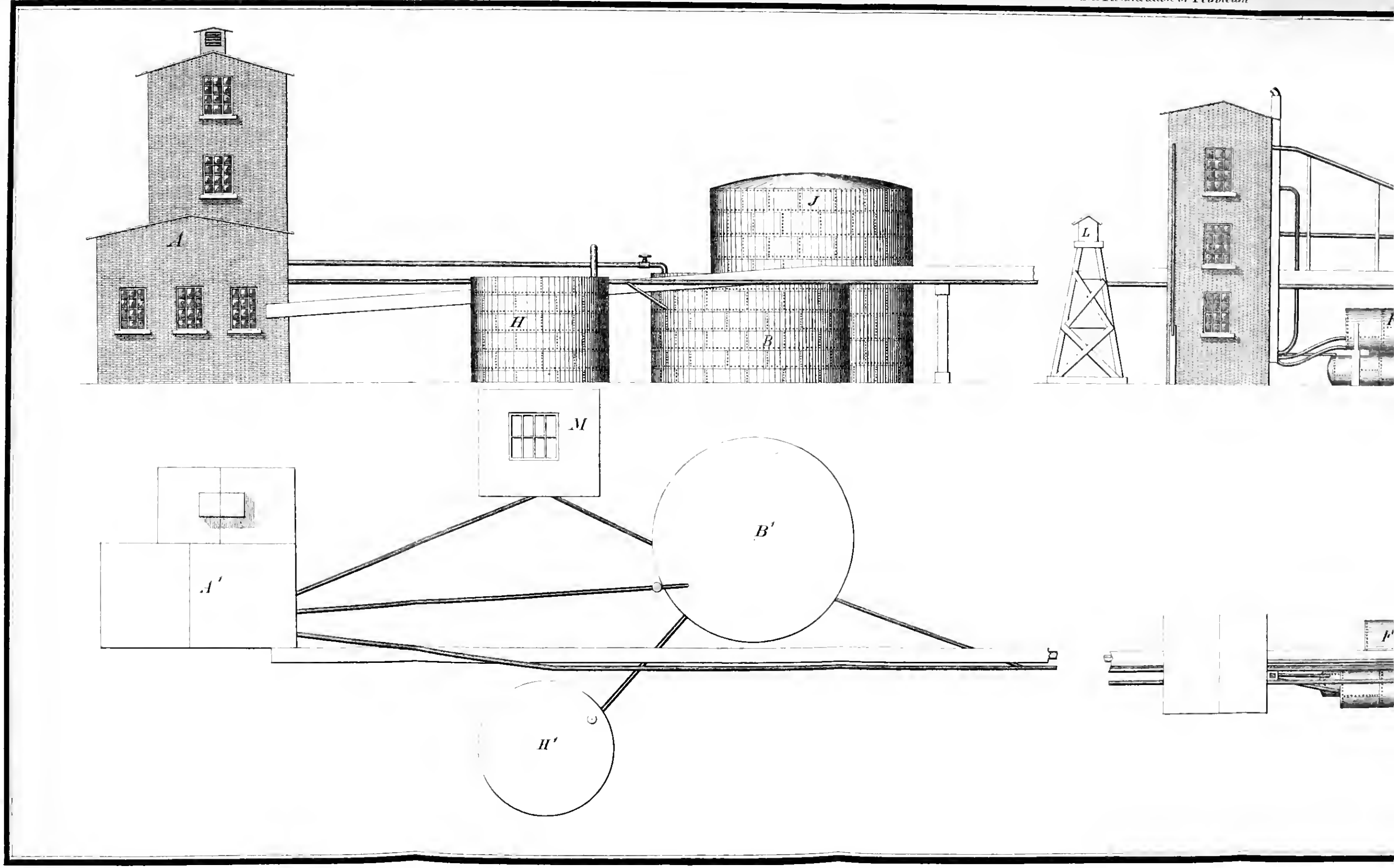
In the course of some investigations upon the petroleum products known as Benzine and Gasoline, I was led to visit one of the leading establishments in Philadelphia in which they are produced, and not being aware of any illustrated description of the process of fractional distillation and rectification as actually practised, determined to obtain the necessary data and drawings for a paper in the *Journal of the Institute*. The establishment referred to is that known as the Franklin Oil Works, belonging to John L. Stewart, located at Gibson's Point, on the Philadelphia, Wilmington and Baltimore Railroad, about a mile below Gray's Ferry, and very near the terminus of the Branch of the Pennsylvania Railroad over which petroleum is brought to the Schuylkill river for shipment. At this point large underground reservoirs exist, into which crude petroleum is run, through pipes, directly from the oil cars in which it is brought from the wells; from these it may be readily transferred to metallic reservoirs on shipboard, or into the receiving reservoirs of the several refineries in the vicinity. The refined kerosene, barrelled for shipment, is also transferred, with very little handling, to vessels lying at the adjacent wharves.

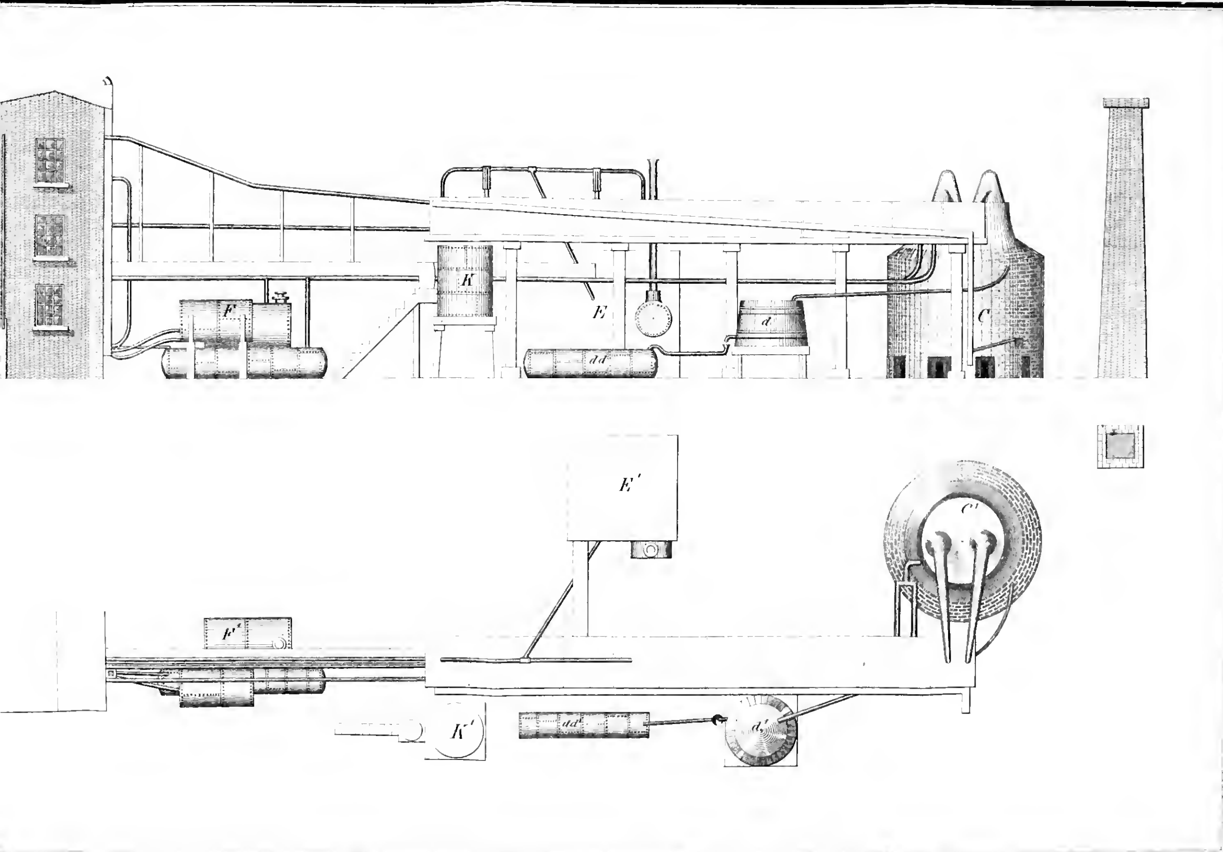
The annexed drawing, by E. Parrish, Jr., C. E., was sketched from the Philadelphia, Wilmington and Baltimore Railroad, on the west side of the works. The entire length of the inclosure is 700 feet, and in the drawing no attempt is made to adhere to a scale, or to represent the whole extent of the establishment. The leading idea in the distribution of the several parts is to secure safety from fire, the chief storage of material being near the northern, and the apparatus requiring fires near the southern end.

In the frame building, A, there are four pumps worked by steam. One of them is for pumping water, one crude petroleum, one kerosene, and one for forcing a powerful current of air into the rectifier and into pipes communicating with the several reservoirs and the still. By these pumps the crude petroleum is transferred from the receiving tank to that marked B in the drawing, and thence, as required, to the still, and the main portion of the distillation is sent to the rectifier, thence to the bleaching house, and thence to the large tank, J, all without labor, loss by evaporation, or danger from fire. The still, C, is located at the southern end of the inclosure: it is of wrought iron, with steel bottom, and holds a charge of 19,000 gallons. It is inclosed by brick work, in which are eight furnaces; this reaches to within about six feet of the top, which is somewhat drum-shaped, and has two necks, through which the vapor is conveyed to the cooler.

Besides these, which carry off the more volatile vapors, there is a pipe inserted lower down in the still, which conducts the heavy lubricating and paraffin oils coming over toward the end of the process through the worm and tub, *d*, to an iron receiver, *d d*. To aid in collecting these least volatile products, which are, for the most part, condensed in the top of the still, a ledge extends around the inside, just at the point of insertion of this pipe. The fuel burned under the still consists of bituminous coal mixed with the tar and coke left as residuum from the process; these resemble coal-tar and asphaltum, though nearly without odor.

The main cooler consists of several courses of iron pipe, running horizontally through a closed wooden trough, eighty feet long, into which a stream of cold water is conveyed by a pipe shown in the drawing, from near the top of the adjacent building, in the basement of which there is a pump for its supply. The inclination of this water-pipe causes it to empty itself whenever the pump ceases to act, thus preventing its bursting when out of use, by freezing. Surmounting


A
H
J
B
L
M
A'
B'
H'


F
K
E
d
dd
C
E'
C'
F'
K'
dd'
d'

the cooler, several small vertical pipes are set on the lower side of the horizontal condensing pipes, for the escape of the uncondensable vapor, which passes off, especially near the beginning and close of the operation.

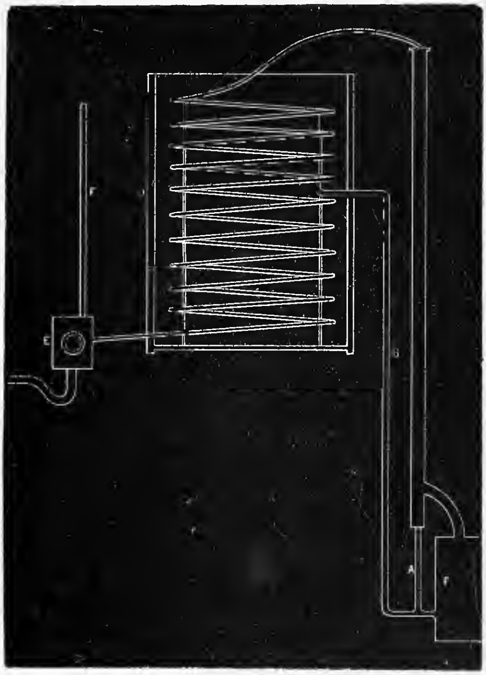
As this heavy vapor, when allowed to escape, is a waste material, and a frequent cause of conflagration, it is desirable to collect and utilize it, for which purpose, over the open end of each of the vertical pipes a pipe of larger bore is set, and these are connected with a main which is led into the adjacent boiler house, E, where a jet of steam is discharged into it in the direction of the fire box, a draft being thus created, by which the highly inflammable vapor is carried under the boiler, and by its combustion made to aid in generating the steam required for working the pumps.

The pipe which conveys the steam to the distant pumps is inclosed in an elevated wooden trough, filled with sawdust to prevent condensation, and this is also used for the support of the pipes connecting the air-pump with the reservoirs and still. The other pipes, used for the conveyance of petroleum, are not buried, but laid directly on the surface of the ground, where any leakage may be easily discovered. The tall frame building to the left of the terminus of the main cooler is appropriated, on the lower floor, to a pump, as before stated; on the second floor is the separator, which is a cast iron box, open at top for the reception of the distillate, and connected, through the bottom, with pipes leading to the receivers for benzine and kerosene respectively. Here these liquids are tested by their specific gravities, and separated previous to undergoing further treatment.

The benzine and gasoline receivers and stills are located near this building, on either side. One is shown in the drawing, marked F. A steam pipe passes into this still, and the still communicates by another pipe with a refrigerated coil in the third story of the above mentioned building. This coil is constructed with a view to separating the distillate to be sold as gasoline from that to be sold as benzine. A pipe leaves the coil midway, through which the more easily condensable portion of the mixed product is collected, while the gasoline, which is only condensed by passing through the entire length of the coil, is delivered into an appropriate receiver, mostly under ground, and covered by a shed.

The annexed figure represents the arrangement for separating the

gasoline. The still, F, which is heated by a coil of steam pipe, connects with a wrought iron stand pipe, 10 inches in diameter, 30 feet high, which conducts the vapor into the worm and cooler. The pipe A conducts back all that condenses in the stand pipe, and the pipe B all that condenses in the first 100 feet of the coil. The water in the cooler, from the line D to the top, is kept at about 80° F., and below that point as cold as possible, not above 60° F. Only the vapor passing this line is fit for gasoline; E is a gas trap, with glass sight-holes; F an escape-pipe for uncondensed vapor.



Following the line of pipe from the separator, and passing the crude petroleum tank, B, we come to the receiving tank for the great body of the distillate, H. The portion designed for kerosene being received here, is transferred to the refinery in the upper part of the building A. This consists of an open wrought iron boiler, lined with lead, in which 225 barrels of the distillate are agitated with ten carboys of sulphuric acid, by means of atmospheric air forced in at the bottom. A strong odor of sulphurous acid is given off during the ebullition, and the kerosene is found to have lost an objectionable adhesive property, and to be less liable to "gum."

Great care is necessary thoroughly to wash out the acid by subsequent continued agitation with water, and lastly with soda. The air-pump being now shut off, the oil rises to the surface, and is drawn off to the bleaching house, which is a large shed, M, shown in the ground plan, having a roof partially of glass, and covering an open tank about 25 feet in diameter. Here the kerosene is exposed to the sun's rays and to a temperature somewhat above 110°

F., produced by a steam pipe, which is protected from contact with it by a three inch cast iron pipe in which it is inserted. The effect of ten thousand gallons of this brilliant liquid, with the sun shining directly upon it, is most striking; the refraction of the light gives to the bottom of the tank the appearance of a constantly changing concavity with the greatest apparent depth nearest the point of observation. The opalescence or fluorescence is superb though, with the exception of this effect, the freshly distilled, rectified and bleached liquid may be said to be colorless.

From the bleaching house the kerosene is forced, by the appropriate pump into the tank, J, not shown in the ground plan, whence it is drawn for barrelling, an operation performed in a large building, omitted from the drawing, supplied with every convenience for its rapid and economical execution.

All the petroleum products are sold in barrels, which are painted blue; each barrel holds about forty-four gallons. But the kerosene is sold by weight, six and a half pounds being the weight of a gallon, and the net weight of each barrel is marked on the outside, by cutting through the paint.

An ingenious automatic faucet is used for filling the barrels; this being inserted tightly into the bung, the escape of air is through it, and as soon as this ceases, from the barrel being full, a leather diaphragm subsides and releases a cut-off held by a cord, so that the flow of the liquid stops.

It remains only to mention two other features of the works represented in the plan. The agitator, K, receives the refuse and any portions of the distillate unsuited to go into either of the finished products, that it may be mixed, and prepared to be returned to the still. The lantern, L, is so elevated as to be removed from escaped vapors, which are apt to collect near the ground; when lighted, it throws a strong light into the separator, a part of the apparatus which it is very necessary to inspect and adjust at night, as well as by daylight.

There are several other buildings: an office, shops, stables and sheds, such as appertain to most factories, which are not represented in this drawing, the object being to convey to the reader an idea of the essential features only, of a petroleum refinery.

The drawing and description of these works has been made without reference to additions now in progress. A large and greatly improved still and cooler are in process of erection, and the pro-

prietor, who is himself the inventor of some improvements, like most successful manufacturers, shows a laudable desire to excel in the completeness of the apparatus and the perfection of the products.

After this description of the apparatus, it will be appropriate to refer more particularly to the process. Twice a week a charge of the crude oil is forced into the still. The fires are then kindled, water turned on to the main cooler, the jet turned into the gas pipe communicating with the fires under the boiler, and the pipes connected with the separator arranged to collect the parts of the distillate designed to be converted, by fractional distillation, into benzine and gasoline. According to my friend, B. J. Crew, who has had experience in this process, crude petroleum gives off nearly incondensable vapor from 60° to 160° F.; from 160° to 280°, the benzine or naptha comes over; from 280° to 600°, the oil suited for illumination; and above 600°, paraffine oil.

During the early part of the process, the specific gravity of the condensed material is taken, from time to time, at the separator, and when it reaches 85° Beaumé the pipe communicating with the gasoline receiver is closed, and it runs into the benzine receiver until it reaches 66° Beaumè, after which it passes on to the large distillate receiver. Sometimes the heavier portions of the benzine is returned to the still, and is thus mixed with the kerosene distillate in the subsequent part of the process, and if there is no market for gasoline, this may also be returned, and may add to the uncondensed vapor consumed under the boiler, and, perhaps, to the available condensed products.

The proportion of the several products may be stated approximately as follows: Gasoline, 8 per cent.; benzine or naptha, 12 per cent.; paraffine, or lubricating oil, 5 per cent., and the remainder is kerosene. The fixed residuum varies in quantity and consistence with the persistence of the operation and the quantity of the crude oil; from one charge of 19,000 gallons an average of about 6½ barrels is obtained. The temperature and mode of conducting the process, however, modify the proportions of the several products. If, toward the last, the heat is pushed, destructive distillation of the tarry mass ensues, and incondensable and difficultly condensable vapors come over, at the expense of the residuum, and it is probable that petroleum tar, like coal tar, yields, at a high heat, a portion of oil suitable for burning.

This essay has already reached its proper limit, and our observations on the uses and properties of the products of this important process of fractional distillation must necessarily be omitted.

ON SOME OF THE CONDITIONS OF LOSS BY VOLATILIZATION IN CERTAIN METALLURGICAL OPERATIONS.

By Charles P. Williams, Prof. of Chemistry, etc., Delaware College.

It is a well recognized fact, pointed out by an expensive experience, that in all methods of lead smelting and in oxidizing and chloridizing roastings generally, a very considerable loss of metals results. This loss is brought about either by the formation of more or less volatile compounds, or by the draught of the furnace carrying, mechanically suspended, particles of chemically changed ore, with the products of combustion, or, in the case of muffle furnaces, with the atmosphere sweeping over the ore therein treated. The problem of devising an economical and complete method of collecting these metallic vapors or fumes is one of very considerable difficulty, and it may be fairly questioned if it has yet received a satisfactory solution. In this country where rich lead ores are abundant, and where all the elements, except labor, entering into the metallurgical treatment of such ores are comparatively cheap; this matter of condensation and collection has not generally forced itself upon the attention of practical metallurgists, but it is nevertheless of considerable significance.

In the treatment of silver-bearing ores by smelting operations, or where a previous chloridizing roasting is necessary, the loss of silver by volatilization must be of significant importance and will yet, if it has not already, give rise to a study of the means adapted to its prevention. Various European experimenters have given different figures for the loss of silver by volatilization in different methods of its extraction, but these figures may safely be averaged as ranging between 0·5 and 4 per cent. of the content of the original ore. With regard to chloride of silver it is well established that its volatility is greatly increased by the presence of other chlorides. Plattner's experiments on the Augustin method of silver extraction,* show that a mixture of 10 parts of oxide of copper, 3 of chloride of lead and 0·6 of fused and finely divided chloride of silver, lost, on roasting in a current of air, 6·61 per cent. of the original weight by volatilization. The sublimate, on quantitative examination, gave 63·8 per ct. chloride and oxide of lead, (containing 54·8 of metallic lead), 32·8 per cent. of cuprous chlor-

* *Berg-und Hüttenmänische Zeitung*, 1854, p. 125, *et. seq.*

ide, (containing 21 of copper,) and 3·4 of argentic chloride, (containing 2·6 of silver). These figures would give 5·09 as the per centage of the loss of the chloride of silver contained in the original mixture, partly due to the volatility of chloride of silver itself, but chiefly brought about, however, by the presence of other chlorides. In the oxidizing roasting of sulphuretted compounds of silver, the loss is also great, through the volatilization of the sulphate, etc., of themselves, or increased by the presence of compounds of other metals, or through the mechanical movement of fine particles of the ore by the draught through the furnaces.

In the treatment of galena for the extraction of lead, whether by the process of reaction or by other means, a large amount of the metal is lost, chiefly in the forms of sulphate or of oxide. This loss, though admittedly large, is not fully appreciated, and is, without doubt, due, not merely to the volatility of the oxide of lead, (this being partially changed into sulphate,) but also to the facts that sulphate of lead is volatile, and that sulphide of lead is readily and rapidly volatilized at elevated temperatures and is subsequently converted into sulphate either through the action of the oxygen of the air or through that of sulphuric acid. This latter production of sulphate is well established by the researches of Plattner,* and his observation of pseudomorphous crystals of plumbic sulphate after sulphide of lead, which had formed after the condensation of the latter crystals from a vaporous condition. The writer of this communication has invariably observed during repeated exhaustive analyses of the so-called Bartlett White Lead, and of oxide of zinc produced at the Keystone Zinc Works, the presence of sulphide of lead. Both of these substances are essentially mixtures of oxide of zinc and plumbic sulphate obtained by the treatment of mixed galena and blende by the well-known process for the manufacture of zinc white directly from the ores. On treatment with hyposulphite of soda the sulphate of lead is readily dissolved, whilst a subsequent addition of dilute acetic acid will dissolve the remaining ingredients, leaving a small amount of dark metallic particles, which, on chemical and microscopic examination, are found to be minute crystals of sulphide of lead.

Mr. Geo. T. Lewis, a well-known manufacturer of this city, has repeatedly completely volatilized several hundred pounds of the purest galena obtained in the Wisconsin lead region. The pro-

* *Procedes Metallurgiques de Grillage*, p. 207, *et, seq.*

ducts of these treatments, (which were chiefly conducted in the Wetherill furnace for the manufacture of zinc white,) were collected by the "bag process," and have been analyzed by the author. They are mixtures of sulphate of lead, (commonly about sixty per cent.,) with some oxide of lead and zinc, and carbonate and sulphite of lead, and invariably contain small and variable amounts of sulphide of lead.* From these experiments the high degree of volatility of this last named compound must be admitted, unless it be claimed that it is first converted into sulphate, and that this salt is even more volatile than the sulphide. The author has made efforts to establish the degree of volatility of the sulphide of lead by strongly heating the artificially prepared salt in currents of nitrogen and hydrosulphuric acid, but has found so many difficulties in the preparation of a perfectly dry and unaltered compound that he cannot, as yet, regard his results as removed beyond sources of fallacy.

Plumbic sulphate is also to a slight degree volatile. Some of the perfectly dry and pure artificially prepared salt was strongly heated for one hour in a porcelain tube through which a current of dry air, freed from carbonic acid, was drawn. Thus treated, 1·4082 grammes of the sulphate lost in weight ·0019 grammes, equivalent to 0·134 per cent. A second experiment with 4·2761 grammes, but heated for upwards of two hours, showed a loss of 8·5 millegrammes, or a little less than 0·2 per cent. Other trials showed variable losses, but in no instance was the percentage amount greater than that obtained in the second experiment. Examined with a glass, indications of fusion of the sulphate were noticed. That this method of producing sulphate of lead in lead smoke or fumes is of much moment compared with that of the volatilization and subsequent oxidation of the sulphide, can hardly be claimed, though it doubtless is one of the many causes of the loss of lead in metallurgical operations.

Another cause of loss is the mechanical one brought about by the currents of air or of the products of combustion sweeping through the furnaces. In furnaces of that description where the fuel is intermingled with the ore under treatment, or where the gases, vapors, etc., from the fuel in the fire box pass over and in contact with the charge, this mechanical loss is doubtless increased

* The method of analysis followed in these investigations was essentially that described by the author in this *Journal* for March, 1869.

by the presence of fuliginous particles of finely divided carbon which enclose, and, as it were, buoy up the denser particles of metallic compounds. Where the metallurgist has to deal with lead ores which contain zinc compounds—by no means an unusual condition of affairs—it will be admitted that the formation of zinc vapors and their subsequent conversion into the specifically light oxide of zinc, will add greatly to the loss of lead as sulphide or as oxide by assisting mechanically in carrying these compounds from the furnace in a manner similar to that in which the sooty particles of carbon may act. The volatility of silver as oxide or as sulphate may be fairly assumed as increased in this same manner. The experiments of Malaguti and Durocher,* made with argentiferous zinc blende, indicate that the loss of silver in the presence of zinc compounds may be very considerable, reaching as much even as 70 per cent. of the original content of the ore, but ranging usually according to the richness of the ore in silver and in zinc, and according to the management of the furnaces, between 15 and 66 per cent.† A small proportion of this loss is unquestionably due to the volatility of the sulphate of silver, but, as in the case of ores not carrying zinc, and not highly silicious, the loss is less than 10 per cent,‡ it must be admitted that zinc compounds dispose silver to volatilize.

The ores mined in the Silurian lime-stones of Sinking Valley are chiefly intimate mixtures of zinc blende and galena, (the latter forming usually about 20 per cent. of the mixture,) and contain on the average, by the assays of the author, about five ounces of silver to the ton of 2000 lbs., though Ashmead finds § by his assays 8·5 and 9 ounces. These ores are treated, at the Keystone zinc works, for the manufacture of zinc white by the ordinary process, and in the residues on the perforated grate bars of the furnace, the writer has never been able to find weighable quantities of silver, though operating repeatedly on amounts of $58\frac{1}{3}$ grammes. By dissolving a weighed amount of the so-called "oxide" made from this ore and collected in the "bags," in nitric acid, evaporating to dryness, adding hydrochloric acid, extracting with water and assaying the residue in the usual manner, 0·014 per cent. of silver may be found,

* *Annales des Mines*, XVII., 1850.

† Plattner, *loc. cit.*, p. 118.

‡ Kerl's *Handbuch der Hüttenkünde*, I., 2d Edition, p. 89.

§ *American Chemist*, Vol. I., No. 4, p. 131.

corresponding to 1·2 ounces to the ton of "oxide." The "Bartlett White Lead," prepared in a similar manner from mixed blende and galena, mined in Davidson county, North Carolina, yields a somewhat smaller percentage of silver, (0·0087 per cent.) though the original ore is more highly argentiferous than that utilized in Pennsylvania. This discrepancy may be accounted for, however, by the fact that the North Carolina ore is roasted (with the addition of salt?) at the mine before shipment to New Jersey for its conversion into the basis of a pigment.

The following analyses will exhibit the composition of lead fumes by various operations:

	No. I.	No. II.	No. III.	No. IV.	No. V.	No. VI.
ZnO	72·083	73·426	49·50	13·80	25·70	9·23
PbO............	·274	......	27·90	10·20	48·30	13·21
SbO_3............	trace.	......	AsO_3 2·10	......	3·90	......
Fe_2O_3..........	"	......	......	3·40	......	trace.
$PbO\,SO_3$......	23·938	25·084	13·00	66·60	11·40	74·05
$Zn\,OSO_3$.......	·810	·574	......	PbS. 1·10	......	trace.
$Zn\,Cl$	·839	......	......	......	.....	......
Fe_2Cl_3.	·071	......	......	......	......	......
$Sb\,Cl_3$.........	trace.	......	......	......	......	......
$Cd\,Cl$.	·256	......	......	......	......	......
$CdO\,SO_3$.......	.....	·187	......	......	......	......
$CaO\,CO_2$.......	...... and	loss ·729	CO_2–7·00	......	4·50	3·27
Clay......	......	......	......	5·60	......	SO_2 ·84
Per cent. Pb in above	16·624	17·132	34·778	56·169	54·571	62·840
Ag......	0·0087	0·014	......	......	......	·0012

Analyses I., II. and VI. are by the author; III., IV. and V. are from Watt's Dictionary of Chemistry, Art. Lead. No. I. is the so-called Bartlett White Lead, (this *Journal*, March, 1869): II. is the zinc white from the ores of Sinking Valley, Pennsylvania: III., fumes from blast furnaces at Freiberg; IV., fumes from reverberatory furnace at Alston Moor; V., from refinery at Freiberg; VI., from Wisconsin ores treated at Birmingham, Pennsylvania, in the Wetherill furnace for the manufacture of zinc white: Nos. I. and II were also obtained by treatment in the same furnace. The three analysed by the author all contained sulphide of lead, but the amounts were small and were not estimated.

Estimates based upon the treatment of a large amount of ores have given the following figures, making evident the loss in the

treatment of lead ores by conversion into merchantable lead, though unfortunately no descriptions of the characters of the ores are furnished: A blast hearth furnace treating 267,008 pounds, yielding by assay 75·75 per cent., or 202,258 pounds, gave 178,895 pounds or 67·00 per cent, exhibiting, therefore, a loss of 23,363 pounds. The refining process gave a further loss of 13·40 per cent, whilst the reduction of the dross from the refinery added a still further loss of 3·60 per cent., giving an aggregate of more than 28½ per cent. of the original content of lead.*

If considerations of the health and property of a neighborhood are only of subordinate importance, such figures must make evident the necessity of connecting, with lead establishments, suitable apparatus for the condensation and saving of this fume. The process of straining the fumes through muslin or fine canvass, which gives such successful results in the collection of zinc fume or oxide as exemplified by the well known "bag process," has not received from metallurgists the attention its simplicity and completeness merit. From experiments made on a large scale on galena ores, both nearly pure and containing a large amount of blende, the writer is satisfied that its application to the condensation of lead and other metallic fumes would leave little to be desired. It seems strange that it has not been applied to purposes other than the mere saving of oxide of zinc, especially when the necessity of a thorough collection of metallic fume is considered. Its satisfactory use in the treatment of sulphuretted ores, it is true, would be somewhat lessened by the fact that the fabric of the bags would be rapidly destroyed by sulphuric acid, etc; but even this difficulty might be obviated by washing the mixed gases and metallic vapors by conducting them into a brick chamber through which water in the form of rain is falling. The water from this chamber might be run off through caustic lime to remove soluble metallic salts. The ordinary blower working in the flues between the zinc furnaces and the bags would prevent any injury to the draught of the furnace.

A discussion of the various mechanical devices and combinations already in use in England and elsewhere for preventing or reducing the loss by volatilization at lead furnaces is not deemed necessary in this connection. The results of Von Patera's experiments† made on a small scale, and having in view the saving of argentiferous fume through chemical reagents and reactions, may yet be found to contain the germs of important technical applications. Especially may this be true of those obtained by the use of sulphydric acid whereby waste sulphurous acid may be converted into sulphur, and a complete saving of volatilized silver and lead compounds be effected.

* These figures are condensed from the elaborate tables in Watt's *Dictionary of Chemistry.*

† *Zeitschrift für Berg-und Hüttenwesen*, 1854, 33.

NEWARK, DEL., December 23, 1870.

EVOLUTION, AS AFFECTING THE EARTH'S CRUST.

[A Lecture delivered at the Franklin Institute, December 8th, 1870.]

By Prof. Leeds

Any one who has visited the lovely falls of Trenton, in the State of New York, will have noticed that the dark blue limestone over which the water falls at the bottom of the glen is filled with the remains of crustaceans and shells. There are multitudes of the tiny rings of crinoidal stems, and sometimes the entire flower-like body and branching arms of the lily encrinite; many species too, of those curious crab-like animals with great projecting eyes like horns, called Trilobites. Now, if any one of us, who chanced to be inclined to the study of nature, had passed his childhood among rocks so filled with fossils as these are, and at the same time so destitute of minerals, he would have turned conchologist. But the school-boys who spend their holidays on the Schuylkill or Wissahickon, the Delaware, Crum Creek, Darby Creek, or the Brandywine, and hammer way upon every rock they meet, never encounter relic of fossil, bird, beast, fish, worm, or shell. They do, however, find minerals, in great abundance and in great variety. I made, some while since, a catalogue of the minerals native to South-eastern Pennsylvania, and found that it included more than one hundred well defined species. If to these the varieties be added, the number does not fall far short of two hundred. There is no large city in the country, New York, Boston, Baltimore, Cincinnati, Chicago, all being included, which possesses so rich a cabinet: one, too, that is accessible to every student, at all times, and free of cost. As a consequence, Philadelphia is, and always bas been, noted for its multitude of mineral collectors and fine mineral cabinets. The collections of Mr. Vaux, Mr. Clay and Mr. Trautwine are excelled by no private, and that of the first named gentleman by no public museum in the country. They contain a number of species which have first been recognized as such from specimens found in this vicinity. Nor is our neighborhood exhausted. A rich field still waits to be tilled by some one who will undertake the labor necessary to carry through the analysis of undetermined minerals to a successful conclusion. South-eastern Pennsylvania, then, is made up of mineral bearing, not fossil bearing rocks, and this is the first important point to which I wished to direct your attention.

The youth who commences his geological studies while rambling through the lovely valleys and over the gently sloping hillsides that encircle our native city, commences his geological studies as nature herself would dictate, were she to become articulate and constitute herself his teacher. The layers of rock, which, piled one upon another, make up the earth's surface, have been frequently and very aptly compared to a series of volumes: the layers which are deepest down, and which, as we shall presently see, were first formed, constituting the introductory books, and those lying near the surface the concluding ones. If the student wishes, then, to understand Geology, he must read these books as nature has written them, and begin with those which she wrote first. Now, one of the very earliest books is in the possession of the students who reside in Philadelphia. Of the second, third, fifth, and many of the later books, we possess but fragments, and must borrow them of our friends who live in New York State and New Jersey, and along the Gulf, if we desire to read them in full. From the first I propose to read, later in the course, some interesting extracts.

These books are written in what the student of general literature would be apt to call the *dead languages* of natural history, its Greek and Latin, so to speak. But there are as many beautiful poems and strange stories told in those dead languages by lips of stone, as Grecian poets sung, and as equally worthy of translation into speech intelligible to those who live at the present day.

The great fire at Alexandria, that burned the famous library, destroyed, it is said, many manuscripts which would have thrown light upon the early history of the Asiatic monarchies. Similar catastrophies, at the beginning of the world's geological history, destroyed a library as great as that which has been left to us. So few are the surviving fragments, that all the sagacity of science is required to re-write that history—and when re-written, it is almost too marvellous to admit of our belief. It tells of a time when the vital and spiritual forces had not yet been set into operation upon our planet—when, from pole to pole, and from peel to core, the earth was given over to the fierce conflict of physical and material powers—when, as yet, the rocks were fluid;—though ten years ago it would have been a rash assertion to make, yet in view of what the spectroscope has revealed to us concerning the constitution of the solar atmosphere, when some rocks were even gases—when these rocks were part, not of the earth, but of the air.

Strangely different, then and now, the earth's atmosphere. Instead of that soft and delicious fluid in which we are bathed, and from which, without labor and without cost, both plant and men drink in unconsciously the greater part of their food and physical energy; that sweet air, which the Greeks called ether, and the very name and thought of which has something poetically associated with it, an atmosphere existed then such as Milton imagined for Pandemonium. It was of vast extent, for the prodigious bulk of water which now constitutes the oceans then existed in the gaseous form, its components, oxygen and hydrogen, being as yet uncombined. In great probability, it contained the oxygen and sulphur, which are now locked up in the rock masses. For, although heat usually *assists* chemical union, yet when it exceeds a certain point, which differs for every substance, instead of assisting, heat *opposes* chemical union; in fact, it becomes the worst foe chemism or the chemical attraction between particles has to deal with. To take an example: if mercury be heated in contact with air to a temperature of 600° Fahrenheit, it takes up oxygen, and becomes coated with a rust, which is known as the red oxide of mercury. If this rust, on the other hand, be heated to a temperature of 750°, it is broken up and resolved once more into mercury and oxygen. If these were chemical lectures, it would be proper for me to state the very beautiful and satisfactory mode by which the modern chemistry explains such apparent anomalies, but we must content ourselves at the present time with a mere statement of the fact. Now, what happens to the red oxide of mercury at 750° happens to every oxide and sulphide at some certain temperature, whether it be 30° of the Fahrenheit scale or 3000°. I feel assured of the truth of this statement, not because I have tested it experimentally in the case of all, or indeed of very many, chemical compounds, but because it follows as a consequence, when certain principles which the modern chemistry regards as of great importance are admitted. Oxygen, hydrogen, nitrogen, sulphur, chlorine, iodine, bromine and the vapors of certain easily vaporisable metals, such as arsenic and tellurium, constituted our atmosphere. At that time it stretched away until it filled a large part of the space included within the orbit of the moon. And if the spectroscope reveals sodium, as existant in the state of vapor in the solar photosphere, why should not sodium, when the earth was in a condition of like fusion, have existed in the terrestrial atmosphere? If sodium, why not the similar metals,

potassium and lithium? The sun's photosphere, so says the spectroscope, contains iron gas, magnesium gas and calcium gas. We conclude then that these and many other metals, of similar density and volatility, once existed upon our globe in the gaseous form. They surrounded the earth's surface in a dense sulpurous atmosphere of appalling magnitude. Other substances, such as gold, platinum, and the noble metals generally, silicon and carbon, the latter of which can be converted into a liquid only at the most exalted temperatures, constituted the fluid body of the earth.

I shall ask you to accompany me one step further back into this dark and misty realm, and look upon the order in which these elements were arranged. This order was connected with a fact which strikes us first of all, when we examine the sixty-four elementary bodies of which the earth, in case its core be of the same composition as its crust, is known to consist. And that is, that some of these elements, such as hydrogen and potassium, are very light, others, like platinum and gold, very heavy, and between these extremes a long series, in which iron, cobalt, etc., occupy the middle position. Would this difference in weight have arranged the earth's surface in layers, and would all the hydrogen have floated at the top, all the nitrogen have formed a second layer, the oxygen a third, the sulphur a fourth, the sodium an eighth or ninth, the iron a thirtieth or thereabouts, and the platinum a fiftieth?

So far as these bodies were gases, undoubtedly not. For we have, to guide us in this matter, the analogy of the earth's atmosphere at the present time. It is composed, as all of you are well aware, principally of three gases, nitrogen, oxygen and carbonic acid. Though the second is considerable heavier than the first, and the carbonic acid much heavier than either of the other two, yet the boldest æronaut who has brought down air from regions where float the feathery cirrus clouds of summer skies, has never yet found a spot, however high, where the proportions in which these gases exist, mingled together in the earth's atmosphere, are not precisely the same as upon the earth's surface. This is due to the fact that the particles of gases are moving at all times in straight lines, with great velocity, and they go on until they meet with an obstacle capable of resisting their motion. In the present instance, one wall of their prison house is the earth's surface, the other is the invisible barrier presented by the force of gravitation.

The case was different with regard to those elements which ex-

isted in a molten state. For we know that the lighter a liquid, the nearer it rises to the surface. I throw out these remarks, as suggesting the reason why the oxides of the lighter metals, such as silica, potash, water, magnesia, etc., should, at the present time, be found upon the earth's surface, while the oxides and sulphides of the heavier elements, such as lead, copper, etc., should have accumulated far below, and have been shoved through cracks and fissures to the surface.

This liquid mass and the huge envelope of gas and vapors that surrounded it, obeyed the same planetary laws of motion then as now. It swept onward through similar realms of space. Astronomy teaches us that these stellar regions are intensely cold. Their temperature is as far below the zero point of our Fahrenheit scale as our mean summer temperature rises above it. And if the earth's atmosphere were swollen with all the ingredients that I have before mentioned, its radiatory surface was of vast area, and the process of cooling went on with great rapidity. There was a time for every element when it reached that critical point in its history of which I have spoken. It cooled down so far that it could enter into combination with oxygen or sulphur, with chlorine, iodine, or whatever element it possessed the greatest attraction for. As soon as these compounds were formed they were precipitated by their weight upon the earth's surface.

(To be continued.)

THE SUN.

(A course of five lectures before the Peabody Institute of Baltimore, January, 1870.

By B. A. Gould.

(Continued from page 71.)

I must recur, before long, to the consideration of the spots: for upon the careful observation of these, a large share of our knowledge of the sun's constitution must depend. There is much to be said concerning their motions, real and apparent, their origin, development, recurrence, &c.; but it seems better first to complete the general description of the sun's aspect, deferring for a while these more detailed points. There is, however, one important fact which must be mentioned here, viz: that the spots are not found on all parts of the sun indiscriminately, but are, with very few exceptions,

restricted to two belts, one on each side of the sun's equator, extending from about 8° to less than 40° of solar latitude, their most frequent occurrence being at the latitude of 20°. Spots are sometimes seen beyond these limits, but well authenticated cases are extremely rare, and the zones within which they are ordinarily to be seen scarcely comprise an area of one-half of the sun's surface. We know, as I have mentioned, and will hereafter explain, that the sun rotates on his axis, like the earth and other planets, and in the same direction. Johannes Fabricius, the first discoverer of the spots, found out this fact also, which had previously been suspected from analogy. The axis of rotation is, according to the best determinations yet made, inclined to the plane of the earth's orbit by $7\frac{1}{4}°$. Did the earth's revolution take place on the same plane as the sun's equator, the spots would appear to be carried, by his rotation, in parallel straight lines across his disk, from left to right. This is indeed the case during the second weeks of June and September, at which times the earth is in that plane; but at other seasons the lines of their apparent motion appear elliptical, in consequence of the effect of perspective upon circles inclined to the line of vision.

Of the faculæ, or patches brighter than the general surface, I have already mentioned the chief characteristics. These bright spots were noted both by Scheiner and by Galileo; and although less attention has been given to their study, and indeed less opportunity for it has existed, than has been the case for the spots, some facts are well established. Though usually elongated and narrow, not only near the middle of the disk as scars, but also in the vicinity of spots, they are by no means always so, but frequently exhibit the most irregular and fantastic forms. There is one class of them which are comparatively small, but well rounded; others are reticulated, and others still have been compared to grotesque attenuated human figures. That they may generally be found near the margins of spots, and especially on that side from which the spots appear to be moving by virtue of the sun's rotation, has been stated; and also that the converse of this statement does not hold good, since faculæ are often seen where no tokens of spots are to be detected. They are not restricted to the equatorial belts in which the latter are in general only to be seen, but may be found at all parts of the surface, although certainly unfrequent near the poles, and most abundant in the spot-zones. Their greater distinctness in the

1″ on drawings = [illegible] inch
1″ on the Sun = [illegible] miles

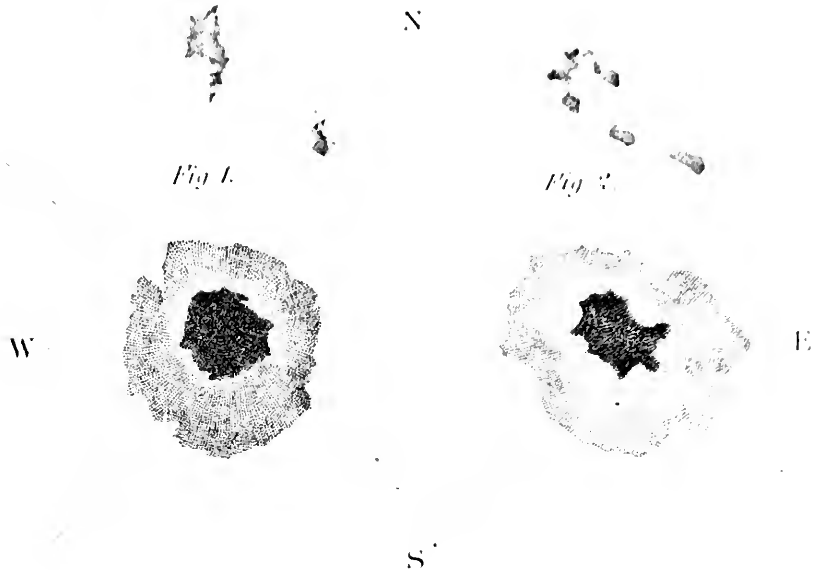


Fig. 3.

Oct. 12th. 9h 30m A.M.

neighborhood of the sun's limb, where the light [illegible] suggested long ago, that they might be elevations, and the telescope, used in the manner already described, exhibit them as floating above the photosphere like clouds. Indeed, there can be little, if any doubt that they are elevated above the general surface, and they have been seen actually to project at the sun's margin like mountains.* Yet, although they gain in relative brightness, as compared with the background, in proportion as they are nearer to the limb, Winnecke, a most trustworthy authority, says† that after they have reached a very close proximity to the border, they, too, fade away like the general surface of the sun in the same position. The photograph of the sun, already exhibited, will have given some idea of the appearance of these objects. Their dimensions vary as greatly as those of the spots. One faculae observed‡ by Herschel was 2¾′ long, which corresponded to a real length of 74,000 miles, being more than nine times the diameter of our earth.

A curious and frequent appearance is that of the so-called "bridges," which often cross a spot dividing it like partitions. Sometimes these are intensely brilliant, crossing penumbra as well as nucleus, while in other cases they are no brighter than the penumbra, and only perceptible when in contrast with the dark nucleus. These bridges are of such frequent occurrence that it is evident they are characteristic phenomena: and no explanation of the spots, or of the nature of the sun, can be deemed adequate which fails to account for them. Both their formation and their disappearance have been frequently observed; tongues of light are seen darting across from one side, or from both sides toward each other, until a bridge is established, in a way not unlike that which naturalists describe when microscopic organic forces are in process of development; and again they are seen to fade gradually away, growing fainter and fainter, until from an intense brightness they have seemed to dissolve and disappear. One of these is shown in Fig. 3 of the accompanying Plate, copied from a drawing, by Mr. Haslett, of a spot seen in October, 1866.

Such are the appearances to be observed with a telescope of moderate power, say with one magnifying not more than one hundred times, and with an object-glass of not more than five inches in di-

* *Monthly Notes R. Astr. Soc.* XX, 56; XXIII, 13. 110; XXIV. 55.

† *Die Sonne,* p. 23.

‡ 1800, Dec. 3. Herschel's measures gave 2′ 45.9″.

ameter. But when larger instruments and higher powers are brought to bear—with good defining capacity, and solar eye-pieces which protect the eye without confusing the delicate details of the image—a new series of phenomena is revealed, and one of the greatest importance for guiding to a knowledge of the sun's true structure.

So long ago as Scheiner's time, the mottled or corrugated aspect of the sun's disk was seen to be due to irregular and very narrow streaks of light. Scheiner himself had observed them, and discoursed upon them in his great work on the solar spots, the "*Rosa Ursina*." Herschel found* that the darker intermediate portions were dotted with small points as black as the nuclei of spots. These points, or pores, as they are often called, appear, in general, nearly round, and are dotted in countless numbers over every part of the surface. They seem to be undergoing continual change, so that an individual point, the position of which is accurately noted at one instant, is at the next moment not to be found; or, in other cases, may have expanded and formed itself into a little round spot without penumbra, such as exist in large numbers, and may almost always be found, on careful scrutiny, in the vicinity of large spots. Indeed, the large spots are not unfrequently developed from groups of these small ones. But Dawes, a conscientious and careful English observer, thinks † that the varying aspect of the pores is due to slight atmospheric fluctuations which bewilder the sight, when the object under examination is so minute. And he says, too, that these points, or pores, have to him the aspect of very small fissures or short dark lines, and are rather gray than black.

About the year 1863, Mr. Nasmyth, of Manchester, the celebrated inventor of the steam hammer, announced ‡ the discovery that, with a powerful telescope of sharp defining power, and under favorable atmospheric conditions, the whole luminous surface of the sun appeared to consist of a thin layer of bright filaments, shaped like willow leaves, averaging about 1000 miles in length and about 100 in breadth; that these lay scattered over the sun generally in every variety of direction, across each other; and that the black points were simply the interstices between the willow leaf filaments. This announcement stimulated at once to very minute scrutiny of the face of

* *Phil. Trans.* 1802, p. 294.

† *Monthly Notices R. Astr. Soc.* XXIV, 35.

‡ *Ibid.* XXIV, 66.

the sun, and to an active controversy among the observers. All agreed that the luminous surface was composed of bright particles, but Nasmyth's description found but little confirmation. One observer proposed the term "rice-grains" as better representing the form of the objects in question; another preferred the word granulations; a third compared them to beach gravel; and a fourth considered *crystals* as the proper term. Many stated that these luminous particles had long been well known to them; but all agreed that they bore small resemblance to willow leaves, and indeed Mr. Nasmyth subsequently modified his original statement by assorting the granules in four classes, one of which was the willow leaf. Huggins, Dawes, Chacornac, Stone and others have observed and written much upon the subject, and the general facts established seem to be essentially those which have been very clearly set forth by Mr. Huggins, of London.*

(To be continued.)

PRELIMINARY REPORTS FROM THE U. S. ECLIPSE PARTIES.

It is yet too early to learn the full results of the observations of the eclipse of 22d December, made by the American observers. Enough, however, has been received to assure us of a very varied fortune experienced in the several localities chosen. The following is the substance of the preliminary reports made by the Naval Professors to Commodore Sands, Superintendent of the U. S. Naval Observatory.

Prof. Hale, by letter of 22d from Syracuse, reports "That the four contacts were pretty well observed. During the total eclipse, thin clouds covered the Moon, making, I think, the physical observation somewhat doubtful. The protuberances were very well seen. They were of a pale red color, and not so bright as I expected them to be. The clouds interfered with my observations of the Corona; I could detect but very little of the radiating and curved streamers given in so many pictures, and the slight radiation that I saw might have been produced by the clouds."

"I need hardly say that the total eclipse was a beautiful sight."

Prof. Harkness writes from Catania, Sicily: "Our latitude and longitude observations together with the necessary triangulation to connect our observing stations in the north bastion at the Prima

* *Monthly Notices R. Astr. Soc.* XXVI, 260

Porta Tessa with the principal buildings in the city, were completed some days before the eclipse. Observations were also made to determine azimuth and magnetic variation. Up to December 20 the weather was very fine; on that day the barometer fell and the sky became cloudy. On the 21st and 22d, however, excellent observations for time were made, and our operations for the eclipse were complete. At its beginning the sky near the Sun was perfectly clear. The first contact was observed at 11 hours, 35 minutes, 27·5 seconds. As the eclipse advanced, the bright line was looked for, which was shown in such a marked manner along the edge of the Moon's limb in the photographs taken at Des Moines last year; but no trace of it could be seen till 12 hours, 8 minutes, when I thought I perceived it.

"Fifteen minutes before totality a dense cloud hid the Sun entirely. The wind was blowing with a force of from 3 to 5; so that the telescope, though sheltered by the parapet of the bastion, was steady, and the lanterns could not be lit near it.

"Within five minutes of totality, the cloud over the Sun fast became less dense. Presently, a thin crescent was all that remained of the Sun, and this dwindled rapidly away, so that at 1 hour 11 seconds I observed the commencement of totality with the naked eye. The cloud was sufficiently thin to allow the Corona to be seen, but diminished in extent and brilliancy, appearing scarcely more than two-thirds as large as that seen in Des Moines.

"With an Arago polariscope in hand the first ten seconds were spent in observing that the sky was polarized all around the Corona, while the Corona itself showed no trace of polarization. Springing to the spectroscope, I saw the green line of which I found the reading to be about the same with that of 1869. The spectroscope directed to many different parts of the Corona by my friend Captain Tupman, R. M. A., showed the same green line.

"During the last few seconds of the totality, the thin cloud covering the Sun became nearly dissipated, and the faint continuous spectrum of the Corona became visible. I could not believe that the eclipse had lasted, according to the chronometer (Negus' of New York), one hundred and fifteen seconds; it seemed a moment only.

"I think that our observations, though made at disadvantage by the high wind and the thin cloud, prove beyond question that the Corona does belong to the Sun; that it is to a great degree, if not entirely, self-luminous, and that its light gives a green line at about

1,471 divisions of Kirchhoff's scale. The observations by the polariscope go to prove that the light from the Corona is not polarized. Five minutes after the totality was over the sky became perfectly clear. The last contact was at 2 hours 19 minutes by the chronometer, which was, approximately, 1 hour 2 minutes 45 seconds slow of Syracuse local mean time."

Prof. Newcomb reports from Gibralter yet more favorably.

"I had chosen a position more than a mile from the town near the southern end of the rock, because the authorities have all agreed that a '*Levanter*' would cover the rock with fog, though it might be clear, both to the north and south. An hour before the eclipse commenced, it rained so hard that I had to cover my instruments; in a half-hour more, the straits were covered with clouds and mists with hardly a patch of sky to be seen except in the north, but 20 minutes later the clouds moved north, leaving some thin places through which the Sun was seen at intervals. I succeeded in observing the first contact which did not occur till about 25 seconds later than the time predicted by Hansen's tables in the British Nautical Almanac, but very near the time of the American Ephemeris. During the intervals in which I could see the Sun, using the lightest shade, I succeeded very well in obtaining transits of the cusps for determining the direction of the centre of shadow.

"I got the commencement of totality very well. During the total phase, the clouds thinned out enough to give a view of the Corona and the protuberances through the flying scud. The observations to which I had intended to devote the two minutes of totality, had reference to the physical appearance of the phenomenon: its form and dimensions, the relative brilliancy of its parts and its apparent structure. I desired to note especially whether it seemed nebulous or whether its light seemed soft and uniform. The clouds, however, prevented my seeing more than this, that the light was perfectly soft and milky without any appearance of cloudiness. The striation so frequently described by observers was certainly not there. There was nothing whatever in the shape of rays to be seen through the scud. The protuberances were very numerous and much more brilliant than the Corona, exhibiting the numerous fantastic shapes shown in the photographs of the last eclipse. Their redness was very brilliant indeed The most noticeable rose up from the Moon like a horn. The darkness was even less than I

expected, as I could read the face of the chronometer within my tent without difficulty.

"During the half hour following the total phase I obtained very good transits of the cusps, and near the end of the eclipse, measures of the distance of the cusps." Altogether the observations may be regarded as successful.

From Prof. Eastman, who had charge chiefly of the Meteorological Observations no report has as yet been received. It will be seen that the impressions given by the floating notices in the newspapers have been unnecessarily discouraging.

The naval professors have not as yet returned to the United States, being engaged under the instructions from the Observatory in visiting and inspecting closely the chief European observatories. The utmost courtesy has been extended to them by the Royal Astronomer, the Radcliffe observer and Mr. Newall, the proprietor of the splendid telescope at Gateshead, and others. Drawings of that telescope (25-inch object glass) have been made by Mr. Newall and forwarded to Commander Sands.

The same courtesy from Sir James Anderson and Mr. Culley, Superintendent of the Government Telegraph, placed the land wires and the Falmouth, Malta and Gibralter Cable at the use of the professors for determining by time signals the longitude of Gibralter, Malta, Catania and Syracuse; and tendered a passage to Gibralter in H. B. M. S. "The Urgent." At Gibralter and Syracuse the Italian authorities offered every facility.

At Augusta, Sicily, they had the pleasure of meeting with a large party of Italian and English astronomers, Father Secchi being one of the company.

We learn from private letters some items of the varying fortunes of other observers. Prof. Peirce, of the United States Coast Survey, and Prof. Watson, of the Michigan University, are reported to have succeeded in getting full views of the totality, at a station happily chosen a few miles out of Syracuse. By a reverse of fortune Prof. Peters, of Hamilton College, so renowned for his discoveries of asteroids, missed the phenomenon, owing to a furious snowstorm at Mount Etna. It is possible that a good view was obtained by parties higher up. But Prof. Hall writes that an English party went up some 5,000 feet, but were in the storm the whole of the totality.

Gen. Abbott, of the U. S. Army, saw nothing, though he went up still higher. Prof. Watson had a clear sky. He went down to Carlentini near the central line and had a full view.

The worst fate seems to have attended the English and French parties who crossed the Straits. Those at Oran had a furious storm around them. M. Janssen, so successful in the eclipse of 1868, saw nothing. He had come out of Paris in a balloon to observe the phenomenon.

Bibliographical Notices.

The Kansas City Bridge. By O. Chanute, Chf. Eng., and George Morrison, Asst. Eng. Illustrated. D. Van Nostrand, N. York.—Following the example of Mr. T. C. Clarke, Messrs. Chanute and Morrison have produced a valuable addition to that class of professional literature which has for its object the simple record of executed works.

It is a pity that so few such books are published, the theoretical side of the question having had almost the sole attention from writers, until there is very little more to be said. An engineer who takes the trouble and pains to relate the practical difficulties under which certain works were carried on, and how these difficulties were successfully met, deserves the thanks of his professional brethren.

In the volume before us, Messrs. Chanute and Morrison have given a detailed description of the Kansas City Bridge, embracing the history of the project, and character of the work in relation to the hydrography of the Missouri river. By far the most interesting feature to the engineer is that of the foundations, which involved difficulties hitherto unprecedented in the annals of American engineering. How these difficulties arose, were met, and conquered, are detailed at great length, and amply illustrated by scale drawings. This chapter is one of great interest and of positive value, since the problem of economically founding masonry in deep water, amid shifting sands and rapid currents, is perhaps the most difficult one with which an engineer has to deal. In regard to the superstructure, there is nothing particularly new, the principal feature being the great draw span of 360 feet, designed and built by the

Keystone Bridge Company of Pittsburg. The draw is wholly of iron, while the permanent spans are a combination of wood and iron, all compressive members being wood, and the tension of iron. Why any wood was used at all in a work of the magnitude of the Kansas City Bridge, we are at a loss to see, as we believe the economy which must have dictated its use to be more fancied than real.

The draw span is open to considerable criticism, since it has been proportioned when closed, as if there were two independent spans on either side of pivot, no reference being had to the continuity that really exists at that point. The necessity for regarding the draw as a beam, supported in the middle, is very apparent, from the fact that a train upon one arm "has caused the further end to rise seven-eighths of an inch." The wedge blocks under the free ends, intended to give a bearing when the draw is closed, have so little lifting power that almost the whole weight continues to be carried by the pivot pier. Mr. Chanute proposes to remedy this error of design by introducing hydraulic jacks under the end posts, by which means sufficient lifting power can be brought into action, and it is to be hoped will in a great measure cause the actual strains to conform to those calculated. The problem of a self-sustaining draw is one of considerable nicety, and perhaps in this country has not received the analytical consideration to which it is entitled. All of the great draws of which we have any knowledge have been computed in precisely the same manner as that of the Kansas City Bridge. Messrs. Chanute and Morrison have candidly called attention to this fact, and they have, moreover, gone mathematically into the question, resulting in a determination to replace the "wedges" by "jacks," as above remarked.

The wisdom of making a draw "self-sustaining" is open to considerable discussion. Except in very great spans, we think the gallows frame draw has superior advantages. Although less pleasing in appearance, the gallows frame is cheaper, easily adjusted, and needs no complicated lifting appliances under the free ends. When a span is large, the expense and inconvenience of carrying up high towers may be easily gotten over by attaching the chains to a point, say a quarter or half span in length from the free ends, in which case the part of the truss beyond the point of support must be made self-sustaining. Such construction has by no means a poor effect, and results in a marked saving for those who have to pay for it, over what would be required for a properly proportioned self-sustaining draw bridge.

Messrs. Chanute and Morrison deserve the thanks of their professional brethren for their contribution to the literature of practical engineering, and their well done has been creditably seconded by their publisher, Mr. Van Nostrand, who has exercised as much good taste in the manner of the publication as the writers have in their matter. We have no doubt that the book will be rewarded with the large sale it deserves. A. P. B.

On the Hypothesis of Evolution: Physical and Metaphysical. By Prof. Edward D. Cope, New Haven, Conn.: Charles C. Chatfield & Co. 1870.

The coldness and disfavor with which the doctrine of development is still received with us is in remarkable contrast with its enthusiastic reception, and almost universal ascendency in the schools abroad. As to the causes of this state of things, a variety of opinions may be urged; but there can be but one, concerning the value of a clear, philosophical review of this most interesting field of modern science. A review of this character we have in the work before us, a fact which the acknowledged ability of its learned author would fully assure.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, November 16th, 1870.

The meeting was called to order by the President, Mr. Coleman Sellers, in the chair. The minutes of the last meeting were read and approved.

The Actuary submitted the report of the Board of Managers, and reported that at the stated meeting held November 9th, donations were received from the Royal Astronomical Society: The Society of Arts, London, and the Steam Users' Association, of Manchester, England.

The report of the Secretary upon Novelties in Science and the Mechanic Arts, was then read, upon which it was announced that the following gentlemen:—Prof. Henry Morton, J. Blodget Britton,

S. Henry Bower, H. W. Bartol, Henry Jacobs, P. F. Moody, W. H. Wahl, D. S. Holman, W. L. Boswell, Albert R. Leeds, Coleman Sellers, John G. Moore, B. Howard Rand, R. E. Rogers, F. A. Genth, Samuel Goforth, Isaac Norris, Jr., W. H. Truman, had been authorized to form the Chemical Section of the Institute.

After which the meeting adjourned. W. H. Wahl,
Secretary pro tem.

Proceedings of the Stated Meeting, December 21st, 1870.

The meeting was called to order by the President, Mr. Coleman Sellers, in the chair. The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their last meeting, held December 14th, they received donations to the Library from the Chemical Society and the Institute of Actuaries, London; and the Steam Users' Association, Manchester, England, and from Prof. Benjamin Pierce, Superintendent of the United States Coast Survey, Washington, D. C. Furthermore, that Messrs. W. B. Bement and Samuel Hart had resigned their membership in the Board of Managers, and that the following members had been, at their request, authorized to constitute the Meteorological Section of the Institute, to wit,—John Wise, W. H. Wahl, Joseph E. Hover, Thomas S. Speakman, Henry Morton, Robert E. Rogers, Hector Orr, B. Howard Rand, Albert R. Leeds, Coleman Sellers, Fairman Rogers, Thomas Shaw, Basil Sewell, Pliny E. Chase, John G. Moore, D. S. Holman, B. H. Moore, Alex. Purvis.

A paper was read by Mr. Hector Orr, upon the details of construction of the proposed bridge between Philadelphia and Camden. This was followed by another, by Mr. John Wise, upon the lightning rod; in which the author contended, by the presentation of a goodly array of statistics, that the rod, as generally attached, frequently acted as an incendiary instead of a protector of our buildings. The paper provoked considerable discussion.

Prof. A. R. Leeds submitted a statement concerning the effects upon the system of inhaling Carbonic Oxide, which was substantiated by Mr. Coleman Sellers.

The Resident Secretary then presented his report on Novelties in Science and the Mechanic Arts, after which the meeting adjourned.

W. H. Wahl, *Secretary pro tem.*

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Editorial.

ITEMS AND NOVELTIES.

The Hoosac Tunnel.—This, one of the most extraordinary engineering labors ever projected in this country, was undertaken with the view of forming a more direct railway connection, and one more central to the State of Massachusetts, between the Hudson river and Boston, than that afforded by the principal route hitherto existing (the Boston and Albany Railroad). The Tunnel route—if carried to a successful culmination, and of this, the untiring energy and engineering talent of the Messrs. Shanly, the present superintendents of the enterprise, furnish the strongest grounds for belief—will have for its western terminus the city of Troy, and will be about ten miles shorter between that point and Boston than the existing route; while in respect to gradients, the tunnel line will have greatly the advantage over the latter, in having no inclines exceeding forty-five feet in the mile, against gradients of from eighty to ninety feet on the other.

The railways of which the tunnel is designed to be the connecting link, are already completed up to the mountains on either side. At the present time and until the completion of the tunnel, stages are in requisition to carry travellers over "the Hoosacs," to complete connections on either side. The westerly portal of the tunnel is at North Adams, fifty miles distant from Troy, and the easterly one is in the valley of Deerfield river, 136 miles from Boston.

The Hoosac Mountain, through the ribs of which the tunnel is being pierced, is, at its highest point along the line, 2508 feet above tide, and the two portals a trifle over 760 feet above the same. Lithologically, it consists, almost throughout, of mica schist, the westerly side displaying for half a mile or less a fault of somewhat altered granite, beyond which again a very hard quartzite is encountered for another half mile or more, which has not yet been fully penetrated. The east end workings, now upwards of 8000 feet inwards, are in unmistakable mica schist, occasional narrow veins of quartz being met with. At the "central shaft," which is located nearly midway between the two ends, and is 1030 feet in depth, the workings are through the same material.

The tunnel is designed for a double line of rails; its length, when completed, will be 25,031 feet; its width is 24 feet; height in centre, 20 feet; and it is graded from each end to the centre 6 inches in the 100 feet, ascending from either end.

The mountain has already been penetrated:

From the east side, ...	8200	feet.
From the west side, ...	5820	"
And at "central shaft,"	200	"
Showing a total progress in the work of .	14,220	"

And leaving still to be accomplished, 10,811 feet.

The daily progress averages at present 15 feet, which it is anticipated will be increased to 18 feet when machine drills have been introduced into the central workings; this, we understand, will take place in about two months.

The system of working varies with the locality. At the east end, where the greatest advance has been made, the work is more simple than at the west end or at the centre. Here (east) the rock is run out by an engine and train of cars, and disposed of in the valley of the Deerfield river. At the east end two operations are going forward. Nearly one-half mile from the portal inwards is in bad ground,

requiring to be arched with brick, the progress of which is necessarily slow, and the appliances for this work taking up the whole space of the tunnel, the rock from the solid workings farther in cannot be run out through the portal. This unlucky state of affairs necessitated the taking of the "bad ground" in the rear, by sinking a shaft, called the "west shaft," 318 feet deep, through which all the rock from the western workings, behind the portion requiring arching with brick, is hoisted. This is effected by a double lift, worked by steam power, one bringing to the surface a car loaded with rock, the other taking an empty car to the bottom. This alternate process goes on with great regularity, a car of rock emerging at the surface every $2\frac{1}{2}$ minutes.

Nearly midway between the ends of this tunnel, and in a deep depression of the mountain, another shaft has been sunk. Its depth is 1030 feet, its shape oval, and dimensions 27 by 15 feet. This is termed the "central shaft," and has recently been completed, and the work of driving the tunnel east and west therefrom commenced. The method of hoisting the rock here is identical with that at the "west shaft;" the machinery is, however, more powerful, and considerable pumping is required to keep the bottom workings free of water.

The drilling is chiefly done by the machine known as the "Burleigh Rock Drill," worked by compressed air, the air compressors being also of the Burleigh Rock Drill Company's make, the drills working either horizontally or vertically, as occasion requires. The material is taken out, full tunnel width, with the aid of eight of these machines, mounted horizontally on two carriages, which are run back—with the drills still in place—far enough to be out of harm's way during the operation of blasting, which is performed twice in each "shift" of eight hours. Of the drills it may be mentioned that each weighs about 540 pounds, and under a pressure of 60 pounds to the square inch will make upwards of 200 strokes per minute, drilling a hole $1\frac{3}{4}$ inches in diameter.

The air power for the drills is obtained through the agency of water power at the east end, and with the aid of steam at the other two points. It is compressed to give a pressure of 65 pounds on the square inch, and is conveyed to the point where it is needed through cast iron pipes, 8 inches in diameter, which are fitted with air-tight joints.

At the east end the work of compressing the air is carried on

upwards of 9000 feet from the point where the drills are in operation, the difference in pressure at the working points being only 2 pounds per square inch compared with that recorded without the tunnel. The exhaust from the drills furnishes a goodly supply of fresh air to the workmen, and the atmosphere of the workings, now 8000 feet from the outer world, is perfectly endurable.

The blasting is principally accomplished by means of nitro-glycerine, manufactured on the place, by Mr. G. M. Mowbray, an experienced chemist. This material, which must be handled with the most intelligent caution, is allowed only in the hands of those who are adepts in its use, and who are employed especially for that purpose.* Though its cost is ten times that of blasting powder, it is nevertheless found advantageous to employ it in certain portions of the works. In the nitro-glycerine blast, the number of holes simultaneously charged varies from ten to fifteen, their depth is usually 60 to 72 inches where the hole is horizontal; where it is vertical, the glycerine charge is put down 10 feet and upwards. These figures will, of course, vary with the nature of the rock and other conditions.

The labor employed in the work is chiefly of the kind termed "skilled labor," the underground workers being, for the most part, regularly bred miners (a large proportion of them being of the very best and most intelligent class of Cornish miners). There are also a large number of Irishmen employed underground, who are highly prized; while of the French Canadians, who are well represented, it is said their aptitude for learning has already made excellent miners of many of them. The overground men employed are chiefly mechanics and American. The employees number about 900, men and boys.

The work is carried on day and night (except Sunday), the twenty-four hours being divided into three working days or shifts of eight hours each.

Such, in brief, is an outline of the nature and present status of this most important work, the rapid and satisfactory progress of which reflects eminent credit upon its talented superintendents.

A new Fire-escape and Ladder.—At the last meeting of the Institute, there was presented and described a contrivance of this character, designed and patented by Mr. Tobias Witmer,

* See a very vivid description of this process in Vol. LVI., page 357, of this *Journal.*

of Buffalo. There are several points in construction for which the inventor claims great rapidity of movement from place to place, ease of attachment and management; these are, that the ladder is mounted permanently on wheels, and is furnished at its lower extremity with a lever. When in use it can be detached from the truck, or forward half of its carriage, readily raised—the angle of elevation being controlled by a rope and windlass attached at the outer extremity of the lever before mentioned—and run rapidly to any needful position. The top of the ladder is furnished with a car, arranged so as to preserve its verticality, at whatever angle the ladder may be, and designed for the reception of a fireman to manage the hose or render assistance, as the case may demand; while on the outer edge is attached a pulley, by which a stout canvas bag is raised or lowered by those below, and in which persons or goods can be taken from the burning edifice with safety. It may be added that the ladders are of the extension plan.

Magnetic Engines—their possible duty.—Attention has been drawn lately, in some of the public prints, to one or more forms of magnetic or electric engines claiming to develop an available and economic motive power. In view of this, it may be of interest, or even of use, if we put before our readers, in a few words and figures, the *possibilities* of invention and improvement in this direction.

The total mechanical equivalent of a pound of pure carbon consumed with oxygen is $7900 \times 1390 = 10{,}981{,}000$ foot pounds,* or in other words, one pound of pure coal burned in one minute would if applied with *absolute* economy to the development of motion, exert a force of $\frac{10{,}981{\cdot}000}{33{\cdot}000} = 332$ horse-power *during one minute*, or if burned during an hour, would exert $\frac{332}{60} = 5{\cdot}5$ horse-power *during the hour;* or again, each horse-power would require $\frac{1}{5{\cdot}5} = {\cdot}18$ of a pound of coal per hour, nearly, or say $\frac{1}{5}$ pound. Now, as a matter of fact, a good engine and boiler does develop a horse-power for each 5 pounds of coal consumed, being about $\frac{1}{25}$th, or say 4 per

*Note.—By Andrews' experiments, one pound of carbon, burned with free supply of oxygen, will heat 7900 pounds of water one degree centigrade. The mechanical equivalent for the heating of one pound of water one degree centigrade is 1390 foot-pounds.

cent. of what it might do if a perfect machine. This shows us that there is a large margin for improvement in reference to the duty of our steam motors, and that if in any other way, chemical force can be converted into motion in a less wasteful way, *some* increase in the costliness of the fuel may not be inconsistent with economy. But this, like any other problem, has its limits, and these it is our purpose to define.

The total mechanical equivalent of zinc is $1301 \times 1390 =$ 1,808,390, or, in other words, a pound of zinc consumed with oxygen in one minute would, if applied with *absolute economy* to the production of motion, develop a force of $\frac{1,808,390}{33,000} = 55$ horse-power, during that time; or, during one hour, $\frac{55}{60} = \cdot 91$, or, say, one horse-power.

Or, in other words, zinc being consumed in such a way that its total useful effect should be applied *without any loss whatever*, would, weight for weight, be about five times as effective as coal in its present wasteful manner of consumption. When, then, zinc is less than five times as costly as coal, and a *perfect* battery and electric engine have been invented, these will compete favorably with the steam engines of the present day.

With reference to some statements that have been published, it may be interesting to note that, from the above data, it is evident that with a *perfect* battery and engine, to develop $2\frac{1}{2}$ horse-power for 10 hours, would demand the consumption of 27·4 pounds of zinc.

Injectors and Pumps.—We observe, in our able cotemporary, *Engineering*, a statement which will no doubt interest many of our readers, namely, that in England and on the Continent hundreds of locomotives are running with injectors alone, and without being supplied with feed pumps also, as is so generally the custom in this country, while hundreds also have only one injector as their sole supply, and yet that occasions of failure even under this last condition are exceedingly few.

Electric Light.—In some experiments made at St. Petersburgh it was found that by aid of an electric light, a target at 1660 yards was so well illuminated that, with an ordinary field-piece, the balls could be invariably lodged as truly as in daylight. Objects at some

distance, on either side of the target, were also rendered clearly visible.

Steel Tyres. A number of accidents which have occurred from the breaking of steel tyres during the late severe cold, draw attention to the fact that a very unnecessary degree of hardness is often given by manufacturers to these parts. The desire to obtain a maximum of mileage among competing makers has gradually led to the use of a steel whose hardness is in excess of what a due regard for security from breakage would warrant.

This, however, is not the only condition involved. The amount of shrinkage should be proportioned to the elasticity of the tyre, and also to the rigidity of the wheel. In rapid running, say of an express train, at 50 miles per hour, the strain developed by centrifugal force amounts to about 4 tons per square inch of section. The shrinkage strain should be a little in excess of this. Now, a steel tyre, of average quality and hardness, on a perfectly rigid wheel, will develop a strain of about 3½ tons per square inch for each $\frac{1}{100}$th inch shrinkage allowed per foot diameter. Thus, $\frac{1}{50}$th inch per foot, or about $\frac{1}{16}$th inch, in a tyre of 3 feet internal diameter, would involve an initial tension of 7 tons per square inch. But the yielding of the wheel which would in practice occur, would probably reduce this strain to 4 tons. These calculations are based on the assumption that the steel will stretch about $\frac{1}{12500}$th per ton of strain. If the steel is harder, however, the strain will be greater, and so the old rules for shrinkage will, with harder steels than those on which they were calculated, develop an undue strain. The change in temperature acting equally on wheel and tyre, has probably little effect in causing the breakage of tyres, which is rather due to the severer shocks developed by the frozen and rigid permanent way. We owe the material of the above abstract to our able cotemporary, *Engineering.*

Boiler Incrustation.—Among the many means proposed for the prevention of this cause of danger, loss, and inconvenience, too little attention has been given to those which might be described as preventives rather than cures. The preliminary purification of water by filtration, and by chemical treatment, such as the precipitation of carbonate of lime by lime water, known as Clark's method, and the use of surface condensers, either of the immersed or of the evaporative type, are worthy of attention in many cases where less effective, and, in the end, more costly means are now in use.

Ocean Telegraph—running speed.—The French Atlantic cable has been occasionally sending as many as 10,000 words per day of 24 hours, but the usual business on the line is about 7000 words daily, or 5 words a minute for 24 hours.

A Screw Propeller Ferry Boat.—The Grand Trunk Railway of Canada has imported an iron ferry boat, with twin screws, to run between Fort Erie and Buffalo and Sermia and Port Huron. She is something over 300 feet long, 45 feet beam, 14 feet deep, and can carry an entire train, with locomotive. She was built at Jarrow, by Messrs. Palmer & Co., and will be put together at Fort Erie by Mr. T. Campbell.

Varied Strain on Railroad Wheels.—From experiments of Baron Von Werder, mentioned in *Engineering*, it appears that the oscillation of six-wheeled locomotives about their central axes, produces such varied strains upon the leading and trailing ends alternately, that in the engines experimented with, the greatest load thrown upon the springs in this way, exceeded the normal load, by 103 per cent. in the case of the leading springs, and 74 per cent. in the trailing springs. These maximum loads are much greater than that allowed by German railroad authorities. The load upon the spring is sometimes reduced during running to about 7 per cent. of the normal load for the leading springs, and to 26 per cent. for the trailing springs. It appears also certain that there are horizontal movements of the vehicles produced at first by partially vertical oscillations. As these horizontal movements towards a rail, may often coincide with a relief of load upon that rail, we have an explanation of widening of gauge and displacement of the permanent way; for, under the circumstances supposed, the opposition of the latter is only that due to its mechanical structure. The difference between the maximum and minimum loads resting at different times on the same springs, varies by more than double the normal load for the leading wheels, but seldom more than 40 per cent. for the trailing wheels. The dangers resulting from this varying and excessive pressure are evident, and demand a system of construction for vehicles which will prevent, or at least reduce, the shifting of load, and such a structure of the permanent way as will distribute the load over a considerable distance.

Bridge across the Hudson River, near New York.—Plans and other preliminaries for this undertaking are in an advanced

condition, and there seems now little doubt that the work will be actually put in hand.

The great obstruction to crossing which has been experienced during this season, from the unusual accumulation of ice in the river, will no doubt give a favorable impetus to the project.

A new Air Engine. In this engine the air is compressed by stages, and passed at each stage through water. It becomes saturated with moisture, and the heat given out by compression is so completely absorbed by the water that under no circumstances the pumps become heated. In the first pump the air is compressed from 1 to 3 atmospheres, in the second from 3 to 6, in the third from 6 to 12, and in the fourth from 12 to 24. From this last pump the air is conducted into a reservoir, whence it passes, in a thoroughly saturated condition, to the coil in the heating chamber. Here the suspended water becomes steam, and the compressed gas is expanded. From this coil the cylinder of the engine is supplied with motive power. In the trial engine the cylinder is $4\frac{3}{5}$ inches in diameter, with a 6-inch stroke, and the effective power over and above that required to work the pumps is stated to be 4 horse power, the amount of fuel consumed being only $2\frac{1}{2}$ pounds per H. P. per hour.

Scientific Lecture on the grand scale.—We see, from the New York papers, that Prof. Morton's lecture on Vision, at the Academy of Music in that city, was a decided success. His optical experiments, developed upon a scale never before attempted in that place, were received with great approbation and enthusiasm. We have been promised a detailed account of his new apparatus and experiments, with illustrations.

Browning's Spectroscope.*—Mr. Browning, the eminent optician, has devised a spectroscope, in which the prisms are automatically adjusted for the minimum angle of deviation for the ray under examination.

In spectroscopes of ordinary construction, when several prisms are employed, a great deficiency of light will be noticed towards the more refrangible end of the spectrum.

This arises from the fact that the prisms are adjusted to the minimum angle of deviation for the most luminous rays which occupy the middle of the spectrum. The effect of this is shown in Fig. 1. P P.

In Fig. 1, P P, &c., represent a train of prisms adjusted as just

* An abstract from the *Chemical News*, communicated by the Editor.

described, for the central portion of the spectrum, and screwed firmly in their places. T represents a telescope, moving round a centre situated at K. In the position in which the telescope is placed, the whole field of the object-glass would be filled with the green light of the spectrum issuing from the last prism; but, when the telescope is removed to the position shown by the dotted lines, either nearer to R or to V (in which case the red end or the violet end of the spectrum would be in the field of view,) then, as we see by the lines, only a small portion of the spectrum would fall on the object-glass. But, it is obvious that, owing to the deficiency in light at the extreme ends of the spectrum, it is just in these very positions that it is desirable that the whole field of the object-glass should be filled. Now this can only be effected when the prisms are adjusted to the minimum angle of deviation for the particular portion of the spectrum which is being examined.

Fig. 1.

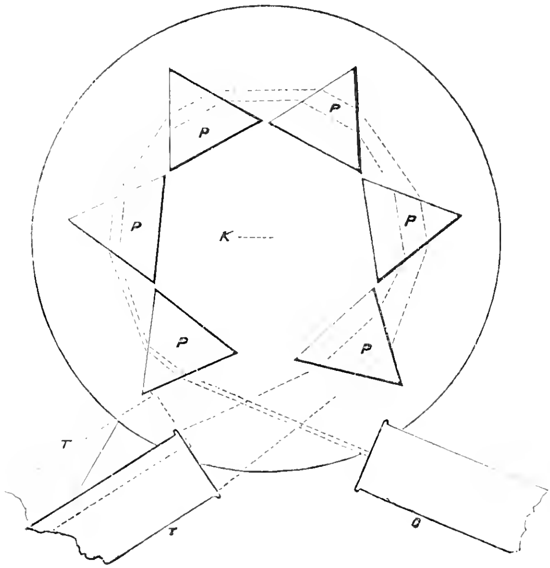


Fig. 2 shows the method in which the change in the adjustment of the prisms to the minimum angle of deviation for each particular ray is made automatically.

In this diagram, P P, &c., as before, represent prisms.

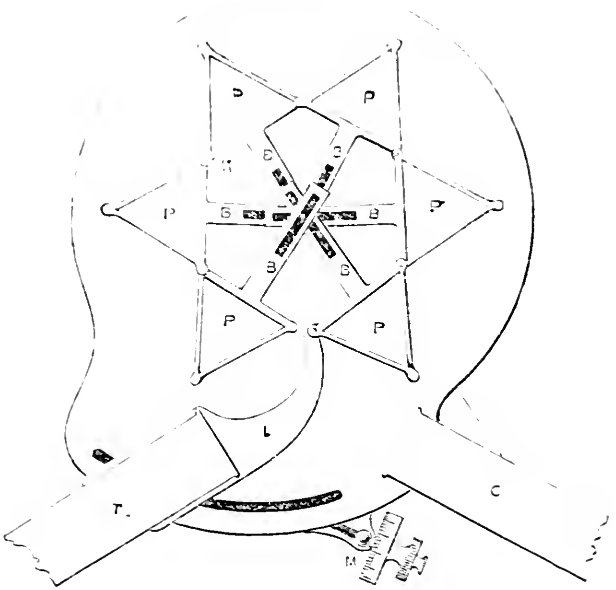
All these prisms, with the exception of the first, are unattached to the plate on which they stand, the triangular stand on which the prisms are hinged together at the angles corresponding to those at the bases of the prisms.

To each of these bases is attached a bar, B, perpendicular to the base of the prisms. As all these bars are slotted and run on a common centre, the prisms are brought into a circle. This central pivot is attached to a dovetail piece of two or three inches in length,

placed on the under side of the main plate of the spectroscope, which is slotted to allow it to pass through. On moving the centre pivot, the whole of the prisms are moved, each to a different amount in proportion to its distance in the train from the first or fixed prism on which the light from the slit falls after passing through the collimator, C. Thus, supposing the first prism of the train opposite C, represented in the diagram, to be stationary, and the second prism to have been moved through 1° by this arrangement, then the third prism will have moved through 2°, the fourth through 3°, the fifth through 4°, and the sixth through 5°. As these bars are at right angles to the bases of the prisms, and all of them pass through a common centre, it is evident that the bases of the prisms are at all times tangents to a common circle.

The contrivance by which this arrangement is made automatic is as follows:

Fig. 2.



A lever, L, is attached to the corner of the triangular plate of the last prism. This lever, by its further end, is attached to the support which carries the telescope through which the spectrum is observed.

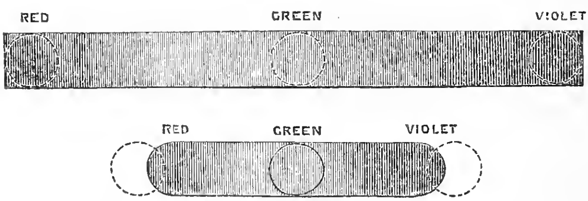
Both the telescope and lever are driven by the micrometer screw, M The action of the lever is so adjusted that when the telescope is moved through any angle it causes the last prism to turn through double that angle.

The rays which issue from the centre of the last prism are thus made to fall perpendicularly upon the centre of the object glass of the telescope, T, and thus the ray of light travels parallel to the basis of the several prisms, and ultimately along the optical axis of the telescope itself, and thereby the whole field of the object-glass is filled with light.

Thus the apparatus is so arranged that on turning the micrometer screw, so as to make a line in the spectrum coincide with the cross wires in the eye-piece of the telescope, the lever, L, attached to the telescope and prisms, sets the whole of the prisms in motion, and adjusts them to the minimum angle of deviation for that portion of the spectrum.

Figs. 3 and 4 represent the appearances presented when looking through the telescope from which the glasses have been removed; in diagram 3 it will be seen that the whole circle of the object glass

Fig. 3 and 4.



is filled with light, as, I have just described, is the case with the new arrangement; while diagram 4 shows the effect of moving the telescope through the angle in front of the fixed prism.*

Coincidence of Terrestrial magnetic change with solar action.—In our November number we published a paper by Prof. C. A. Young, in which an account was given (among other things) of the sudden outburst upon the surface of the sun of a luminous

* It is with no wish to detract from Mr. Browning's credit, but simply to put before our readers the *fullest* information on each subject, that attention is called to the fact that Mr. L. M. Rutherfurd published in *Silliman's Journal* for March of 1865, an account of a spectroscope which involved the most important feature of the above, namely, the connection of the prisms by their bases and the attachment to these bases of bars with slots sliding on a common centre pin.—H. M.

cloud, whose shape and dimensions, as seen in the spectroscope, was represented in Fig. 9 of the same article. This outburst occurred exactly at 4·05 P. M. on September 28th.

In a letter just received from Prof. Young he mentions that on a careful examination of the magnetic record which is automatically kept at Greenwich, England, he found a sudden and marked inflection, amounting to no less than 5 minutes of arc, to have been produced exactly at this same instant of time.

A similar incident to this, but less definitely noted, was recorded by Herschel. See this *Journal*, Vol. LIV, p. 55.

Approach caused by Vibration.—It was first observed by Frederick Guthrie, that a delicately suspended piece of card-board. moves from a considerable distance towards a vibrating tuning fork. At first it seemed natural to suppose that this was the result of such small whirlwinds as Faraday had demonstrated to be the cause of inter-nodal accumulation of light particles on vibrating plates. A series of experiments, however, showed that these currents did not exist in the positions or reach to the distances demanded by this hypothesis.

One prong of a fork being enclosed in a tube connected with a simple tube, dipping in water, it was found that an expansion of the contained air was the immediate result of vibration in the fork.

Mr. Guthrie concludes, from the suddenness of this change in volume, and of its disappearance, that it was not due to heat developed by motion in the air. We do not, however, agree fully in this conclusion, as, under the conditions of the experiment, this gain and loss ought to be very rapid, and, on general principles, ought to occur.

Other experiments seemed to fail in demonstrating that a specific decrease in density was produced in an elastic medium by the development of sonorous vibrations therein, although such a result would seem to be a necessary consequence of general theory. We should doubt, in this case, if the delicacy of the test applied was sufficiently great.

The author finally concludes by what is little more than a general form of expression for the fundamental fact, namely, by stating that the dispersion of vibration between fixed surfaces produces effects similar to the dispersion of air currents under like conditions, (as in Clément's experiment, known as the pneumatic paradox, in which air emitted from a tube with a broad flange against a disk causes

the latter to approach,) and then farther generalizes to the effect that emitted heat vibrations might cause the approach of bodies, a conclusion, we think, very far from being warranted by the preceding facts and inferences.

Remarkable color change produced by heat in certain Iodides.—We have received from Prof. G. F. Barker specimens of the curious iodides of silver and of copper lately discovered by Meusel. The first of these is prepared by adding a solution of silver nitrate to one of mercuric iodide in potassium iodide, and is of a bright lemon-yellow color, changing by a heat below 212° to a rich orange, and regaining its original tint when cooled. The second is prepared by adding to a warm solution of mercuric iodide in potassium iodide, first copper sulphate and then sulphurous acid. Its color is carmine, becoming black, however, at a temperature of 158° F., but restored on cooling.

Mixed with gum water and applied to paper, these bodies exhibit their changes of color in a most striking manner.

Leaden Bullets melted by impact.—It will no doubt be remembered by some of our readers that when a stream of bullets was directed against an iron target from Perkins' steam gun, a homogeneous mass of lead was produced by the partial melting and reunion of the mass. In No. 7 of *Poggendorff's Annalen* for 1870 we find detailed record of a similar phenomenon, as observed in some experiments at Basle, where bullets weighing 40 grammes were discharged against an iron target at 100 paces. The bullets, after impact, weighed only 13 grammes, the remainder being melted and scattered about in a form bearing witness to its fluid condition. Mr. Ed. Hagenbach calculates the amount of heat which should be developed by the impact of the 40 guns, at a velocity of 320 metres per second, and finds it to be ·49 units, while the heat required to raise the temperature of the ball from 100° C, its presumable initial degree, to the melting point of lead, 335° C, and for fusing 27 grms., would be ·44 units. Thus showing, as might be supposed in advance, from the suddenness of the action, that almost all the heat developed is applied to this heating and fusion, and but little expended in producing motion in the target, or lost by radiation.

Boiling produced by commingling immiscible liquids.—In consequence of the fact that (as shown by Magnus) the vapors of liquids which do not mix obey Dalton's law of diffusion, the common tension of such vapors (as bisulphide of carbon and water) in a

state of saturation is equal to the sum of the individual tensions for the temperature in question. For example, bi-sulphide of carbon alone boils at 119·8 F., with a tension at this point of one atmosphere. The tension of water vapor at the same point is 0·11 of an atmosphere; the sum of these is, of course, 1·11 atmospheres, which would clearly imply an energetic ebullition in a mixture of bi-sulphide of carbon and water at this temperature.

That such a result would actually follow, may be readily illustrated in the following manner: Let a vessel of about one gallon capacity be filled with water at a temperature a little below 119·8 F., and a test tube partly filled with bi-sulphide of carbon be immersed and stirred about in the same until it has acquired an equal temperature. No boiling will occur, but if the contents of the test tube be now poured into the water a brisk ebullition will at once take place.

The maximum of Magnetic Power evolved by a Galvanic Battery.—A curious succession of papers on the above subject have appeared lately in the *Chemical News*, from the Rev. H. Highton, in which that gentleman attacks no less important a principle than the conservation of force, and maintains no less difficult a thesis than the possibility of what is technically called perpetual motion, or the development of power without a corresponding expenditure of force. The subject would hardly be worthy of our notice but that, strange to say, these opinions have gone, so far, unchallenged in the pages of our learned cotemporary, and, in connection with schemes alluded to in another item on galvanic motors, seem to have led astray some investigators.

The theory of the daring author above-named, is briefly this: A battery current, passed through a given electro-magnet, will lift a given weight; if, now, we double the cross section of the wire of said electro-magnet, and also its length, the resistance of the circuit remaining the same as before, the current developed by the battery and the consumption of zinc will remain as before, and yet the lifting power of the magnet will be doubled. Or, in place of increasing the size and length of wire, several similar electro-magnets may be so introduced in the circuit as to produce the same effect. Such a process continued indefinitely would, of course, enable us to develop any amount of magnetic force from a given battery.

So far, well; but we have not yet come to the development of power, which implies motion. For this, it is evident that the

electro-magnet must be charged and discharged, and here comes the compensating condition. To charge a *double length* of wire will take just *twice the time*, and therefore cause a *double expenditure* of zinc in the battery.

Our author, in fact, notices this, but remarks that "the electric current is so rapid that this difference of time is inappreciable within any practical limits." Without doubt, to advocates of perpetual motion, but not to those who can see that two millionths of a second are as much twice one millionth as two centuries are twice one; or to the zinc, which, having to work twice as long at each effort, will be doubly exhausted when a given number of actions has been completed.

Gold Refining by Chlorine.—On page 13 of our LVIIIth Vollume we noticed the introduction, in the Australian Mint, of this process, with marked success. We now hear, from the best authority, that the inventor of the process, Prof. Miller, of the Royal Mint in Sydney, has just been putting up and working the apparatus in the Mint at Philadelphia, with very satisfactory results.

A bar of some 500 ounces, containing antimony, which rendered it very brittle and 7·80 fine, was refined in one hour and a half to a fineness of 9·97, and made perfectly tough, every trace of antimony having been removed.

The impure gold being melted in a crucible previously saturated with melted borax, and having a layer of fused borax over the metal, the gas is generated in a stone-ware vessel, and led by a flexible hose to a pipe-clay tube, by which it is carried to the bottom of the metal. All the chlorides of antimony, tin, &c., are so volatile at the temperature employed as to escape, but the silver chloride is retained by the layer of borax, and is poured out into moulds after the gold has become solid on cooling.

Reducing Silver Chloride.—In connection with the process for refining gold, described above, an excellent method for reducing the silver-chloride obtained in that operation has been perfected by its inventor, Prof. Leibius, Assayer of the Mint at Sidney. The silver-chloride is cast in flat plates, and then arranged in a box or frame, with alternate plates of zinc coupled as for a galvanic battery. The whole being immersed in water, a galvanic action is set up, the reduction is soon finished, and the silver is so compact and free from zinc that, without acid treatment, it may be carried to the melting pots.

Civil and Mechanical Engineering.

IRON MANUFACTURES IN GREAT BRITAIN.

SECOND PAPER.

By R. H. Thurston,

First Asst. Eng., Asst. Prof. Nat. Philos., U. S. N. A.; Member Institute.

The "Royal Navy" of Great Britain, like its merchant navy, is now composed, in its effective force, almost exclusively of iron steamers. Wooden vessels are not built, for all the reasons that apply in case of merchant ships, and for the additional reason that such weight of iron armor as has become necessary would prove very destructive to a wooden hull, even were the wooden hull capable of sustaining the strain of the immense steam power required for speeds of from twelve to sixteen or seventeen knots.

The war vessels built by Great Britain for some years past have been iron-clad, with the exception of a few transports, and several ships built with the intention—which was not realized, however—of competing with our own "Wampanoag class" in speed, regardless of their other naval qualifications.

In her navy of over six hundred registered vessels of all classes, she has now forty-seven iron clads, of which thirty-three have iron hulls, and of which more than-three-fourths are broadside ships. Their side armor varies from $4\frac{1}{2}$ inches in thickness in the older broadside vessels, to 14 inches in the turrets of monitor iron clads now building. Their armament has its maximum in the "Hercules," which carries eight 18-ton X-inch rifles, two 12-ton IX-inch, and four $6\frac{1}{2}$-ton VII-inch rifles, all of the Woolwich pattern.

The hulls of the later iron clads are of immense strength, and yet of comparatively light weight, their lightness in both hull and machinery enabling them to carry great weight of armor on a relatively small displacement. For the ingenuity which has so greatly and advantageously modified the details of construction of the hull, credit is very largely due to the energy and boldness of a talented engineer and naval architect, E. J. Reed, until recently, Chief Constructor of the British Navy.

The extreme lightness of machinery is obtained by high piston

speed and by great care in proportioning details; the boilers are forced to the utmost possible extent. The weight of engines and boilers with water has been in some cases brought below 300 pounds per indicated horse-power. Sharp competition between rival building firms and good engineering have given rise to rapid improvement, and have compelled the introduction of higher pressure, greater expansion, surface condensation, tubular boilers, and moderate superheating.

The style of engine is usually either the trunk engine, as built by Messrs. Penn & Sons, or of the ordinary "return connecting rod" type. The steam is usually carried at about 30 pounds per square inch in the boiler: in a few cases, one of which was given in the preceding paper, much higher pressures and the compound engine have been tried, by way of experiment, with, on the whole, very favorable results. It must be remarked, however, that the introduction of higher steam and greater expansion in new styles of engine has been, and will probably continue to be, retarded by the necessity of training men to manipulate successfully the new machinery, precisely as the introduction of surface condensers—now deemed so generally indispensable—was for years retarded.

A tolerably accurate idea of British design and proportion in constructing both hull and machinery may be obtained by reference to the description of the iron clad "Monarch," in the April, 1870, number of this *Journal.*

The cellular structure and bracket plate system of ship construction there described is adopted in all lately built iron clads and large vessels, and the proportions of machinery as there given are about the same as are generally adopted by the well known firms.

Although, as a general rule, the broadside iron clad has been adopted in the British navy, there are a few monitor iron clads afloat, and a number of others are building, in compliance with the feeling in their favor awakened by a strong party, headed by the late ill-instructed and unfortunate, but zealous inventor, Capt. Cowper P. Coles, R. N.

Those built since the "Monarch" are true Monitors, without masts and sails, and some of them are very formidable fighting machines. The loss of the "Captain" has caused a not remarkable, but somewhat unreasonable distrust of all ships of the monitor type; no more will probably be built of the "Monarch" class, and even the true monitors—without sails—are looked upon generally with much

the same feeling that was shown in our own navy when this class of vessels was first introduced.

One good effect that has followed the loss of the Captain is the commencement of a careful investigation of the stability of all British iron clads by experiment. There are some indications that their designers have sometimes been satisfied with obtaining a good height of metacentre above the centre of gravity without noting carefully its variation of position with the movements of the vessel, or laying off the curve of stability. It seems quite certain that in some classes of ships stability is seriously lacking, and orders have issued from the Admiralty, directing, in such cases, the use of a permanent ballast of iron concrete in the spaces of the cellular bottom.

The favorite style of turret iron clad is what its designer calls the "breastwork monitor," of which we gave a sketch in Fig. 1, the parts above the *dotted* line C C indicating armor.

FIG. 1.

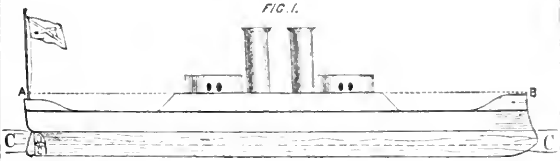
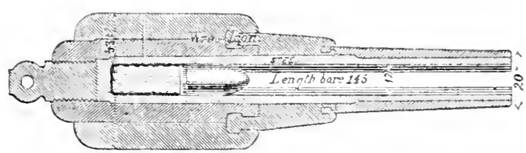


FIG. 2.



The breastwork rises some six feet above the main deck of the vessel, and in the deck which covers it are the hatches, and through it rise the ventilators and smokepipes. There seems to be no reason why the same deck should not be carried fore and aft, as indicated by the dotted line, A B, and the covered but unarmored space thus utilized would be most valuable in these ships, which are invariably very much cramped in space below decks, and the change would greatly increase their stability. In one case, at least, this improvement is ordered.

The most formidable of these vessels are the "Devastation" and the "Thunderer," building respectively at Portsmouth and Pembroke dockyards, and now well advanced. These ships are 285 feet long, of 62½ feet beam, and will have a draught of 26 feet; their tonnage is given at 4406 tons. Their side armor is 12 inches thick, in single thickness, along the water line, and on breastworks, and somewhat thinner below water; the armor rests on teak backing, 18 inches thick, and an inner skin 1½ inches thick; the deck rises 4½ feet above water. The turrets are 31 feet in diameter, armored with 14-inch plates on the side through which the ports are cut, and 12 inches on other parts, backed with 15 and 17 inches of teak on an inner 1¼-inch skin. The bow is of immense strength, for the purpose of being used as a ram. These powerful craft carry four 30-ton XII-inch rifles, in two turrets, at a height of 12 feet above water; the shot fired by these guns will weigh something over 600 pounds, and will be propelled by 100 pounds of such powder as is used in the 70-pound cartridges of the "Monarch's" guns. The vessels are intended to have a speed of 12½ knots per hour, and to carry 1600 tons of coal in their bunkers, a quantity sufficient for, probably, ten days steaming; they have twin screws, driven by engines of 800 nominal horse-power collectively.

The most powerful *broadside* ships are the sister ships, "Hercules" and "Sultan." The structure of their hulls is quite similar to that of the "Monarch," and their armament has already been stated.

Their armor has a maximum thickness of 9 inches along the water line, 8 inches over the casemates, and 6 inches on the sides generally, backed with 12 inches of teak backing on a 1½-inch skin; along the thick water-line belt, a further protection of 30 inches of teak on another ¾-inch iron skin is added inside the hull. Their speed is from 13 knots at sea to 14¾ knots on the measured mile, on a displacement of 8,680 tons, a draught of 25 feet water, and driven by engines that have, in the "Hercules," indicated as high as 8,528 horse-power. This immense power has been developed with a consumption of 25 pounds of steam per H. P. per hour, as calculated from indicator cards; the grate surface is 907 feet square feet, heating surface 19,800, superheating surface 3,900, and condensing surface 20,768 square feet. The engines have cylinders of 127 inches diameter, and 47-inch trunks; stroke of piston, 4½ feet. Their weight, with that of boilers and water, is given at 1095 tons.

The machinery of both ships is from the same design, and is built by Messrs. Penn & Sons.

Visiting the "Sultan," at Chatham, we noticed the same absence of useless finish and ornament about the machinery that is almost invariably to be observed on British war vessels. The general design and arrangement and the proportions are admirable, and the workmanship excellent.

Two unarmored gunboats are just added to the British navy, which are remarkable for carrying, on a very small hull, a very large gun; they are of 85 feet length, 26 feet beam, and 9 feet depth of hold, measuring 244$\frac{31}{94}$ tons O. M.; they each carry one 18-ton X-inch rifle, and will probably prove very useful as well as inexpensive craft for harbor defence.

The 178,000 tons of vessels which constitute the British iron clad navy carry 590 guns, discharging 62,000 pounds of shot. These guns consist entirely of Woolwich rifles, the most powerful being the XII-inch rifles ordered, but not yet supplied, for the "Devastation" and the "Thunderer." One now about ready weighs 35 tons 7 hundred weight, measures 4 feet 8 inches across the breech, 1 foot 9 inches diameter at muzzle, and will cost about £2500. It is constructed on Frazer's modification of the Armstrong system, as are all large guns made at Woolwich; if made by the old method its cost would have been about £3500. Fig. 2 is a sketch of the "Monarch" pattern of XII-inch gun. The "*energy*" of the shot* from the gun just described will probably be about 7000 foot-tons at 1000 yards from the gun, and they will probably be capable of penetrating armor plate 15 inches thick, using charges of 100 or 120 pounds of powder.

The armament of the turret ships generally consists of 25 ton XII-inch rifles, and the heaviest guns in broadside are the 18-ton X-inch rifles. The latter throw a shot of 400 pounds with a velocity of 1200 to 1300 feet per second, and with a power sufficient to penetrate about 13 inches of iron; their "energy" at 1000 yards is still 3500 to 4000 foot-tons; the charge of powder is 60 pounds of English "large grain rifle powder." Less powerful vessels carry 12-ton IX-inch, 250 pdr. rifles, which are capable of penetrating, with a 45-pound charge, 11 inches of armor plate.

The guns made at Sir William Armstrong's "Elswick Works,"

* The first of these guns has been tested since the above was written, and the "energy" at 1000 yards is considerably above even the figure given.

as well as those made at Woolwich, are "built up guns." The inner tube is usually made of a mild steel, from the works of Messrs. Firth & Son, Sheffield. This steel tube is relied upon principally for longitudinal strength, and has also sufficient hardness to bear the severe friction of the shot without injury. Outside this steel tube are fitted a number of wrought iron bands, which are made of coiled bars welded together, somewhat like the old "stub twist" barrels. The bands are "shrunk on," the gun being kept cool during the operation by a cooling stream of water on its interior surface.

At the Elswick Works, near Newcastle-on-Tyne, where we were very kindly received by Sir William Armstrong and Capt. Noble, we found guns in process of manufacture for nearly every European government. All large guns were muzzle loaders, but army, battery, and siege guns, up to 40-pounders, were breech loading. We noticed here, as in many other large establishments, that all wrought iron chips and shavings were carefully gathered up and worked into blooms, in either reverberatory or open furnaces, a piece of economy that is less often noticed among our own iron workers. We noticed at the Elswick Works a Moncrieff gun carriage that, we fancied, looked rather weak at one or two important points; it would be very unfortunate if so excellent an invention were condemned in consequence of imperfection in design. All gun carriages were of iron, and were fitted with what is called, in England, the *Armstrong*, but in this country the *Ericsson* compressor.

The Armstrong and Woolwich guns are perhaps as strong as ingenuity and fine workmanship can make them with such materials, but it is evident that their numerous welds, and the varying strains liable to occur in shrinking on their bands, are seriously objectionable, and it consequently happens that the charge of the 25-ton gun is but about one-thousandth, and the weight of shot but one-ninetieth, the weight of the gun.

In many respects the *Whitworth* system of ordnance seems preferable, even if we take exception to the polygonal bore. Through the kindness of Sir Joseph Whitworth and of Mr. E. J. Reed, who had resigned his office of "Chief Constructor of the British Navy," for the purpose of joining the Whitworth Company, we were enabled to inspect their works and methods.

The Whitworth gun, as now made, is built up in a manner somewhat similar to the guns we have described, but steel is used en-

tirely, instead of wrought iron, in the band[illegible]. Form[illegible] was made, in all its parts, of Firth steel, like that [illegible] W[illegible] for inner tubes, but recently the "Whitworth [illegible] has been adopted. The compression of the met[illegible] steel," or "homogeneous metal," is effected while it [illegible] in the mould, by an ingenious method of applying the [illegible] force of a hydraulic press. This pressure, which has been carried up to 8 tons per square inch, and which will be increased to 20 tons per square inch, should it be found possible to sustain such a strain, by using moulds encased in the compressed metal, closes the pores, which ordinarily are found so seriously to injure the strength of steel castings, and the metal is given a homogeneity that is usually only obtained by forging under a heavy hammer. It is claimed that a metal can be thus obtained that can be relied upon for a tensile strength of 100,000 pounds per square inch, and a capability of stretching 25 per cent. before breaking. A metal which unites such high tensile strength and great resilience is evidently excellently adapted for ordnance purposes.

The several bands of the Whitworth ordnance are forced on, after being fitted with remarkable nicety, by means of the hydraulic press; the desired "initial tension" is thus obtained with great accuracy. The strength of these guns may be inferred from the fact that the charge of powder is usually about one seven-hundredth, and the weight of shot about one-*sixtieth*, of the weight of the gun.

Its penetration and range are probably, with equal weight of gun, about 20 per cent. greater than the Woolwich gun. It need hardly be stated that engineers generally seem to consider the Whitworth superior to the Woolwich system of ordnance. The opposition of the friends of the latter system, and the expense of making a change, have, however, prevented an extended trial of the Whitworth system by the British navy or army.

From what has been stated above, it will be seen that the later vessels of the British navy are exceedingly formidable craft, and that navy, taken as a whole, although not as effective as it was intended by the Admiralty to be, is by far the largest and most powerful navy in the world. In the constructor's department of the Admiralty, Mr. E. J. Reed has left designs for turret iron clads which are calculated to carry 18 inches solid armor upon their sides and 20 inches on their turrets. Such vessels could not be built in the United States until after the expenditure of millions of

dollars in building rolling mills and iron-ship yards, and unless legislation soon causes a commencement, we shall fall hopelessly behind foreign nations in the effectiveness of our navy.

The British government are not so well satisfied with the condition of its navy as to suspend all action towards its further extension, but continue to increase and strengthen it systematically. They propose to add 20,000 tons of iron clad ships yearly to its force, besides transports and unarmored vessels. By her far-sighted policy of liberally subsidizing her lines of steam communication with foreign ports, Great Britain has also almost monopolized the profit derived from the carrying trade of the world in time of peace, and, at the same time, has secured the immense advantage of being able to recruit her navy, in time of war, from the large body of fine officers and seamen, and with the fleet steamers of a wonderfully expanded mercantile marine.

Should no change take place in the policies of Great Britain and the United States, in regard to sustaining and increasing their respective navies, a contrast, most unfavorable to our own country, will soon be presented. Great Britain cherishes her navy with jealous care, and takes advantage of every improvement in construction that science and art can suggest; the navy of the United States, on the other hand, is rapidly losing its efficiency by the decay of its vessels, both of wood and iron, while, in spite of repeated appeals from the Navy Department and from citizens and officials abroad, no action has yet been taken by Congress toward repairing losses or making our naval power commensurate with that of the more important European nations, or toward the re-establishment of a merchant navy which shall become a source of profit in time of peace and an insurance against losses by war. In the event of a foreign war, we may yet find ourselves compelled to call in our ships to defend our harbors, and to remain absolutely powerless for offence.

In the manufacture of steam engines, other than marine, there is, perhaps, not very much that is novel to attract the attention of an American engineer, but he may still find it profitable to spend some time among the English engine building establishments, observing their methods rather than studying designs.

In building *portable* engines, several firms have obtained remarkable economical results.

The favorite style of portable engine is mounted on its boiler, as

is usual with our own builders, but it is almost invariably provided with a steam jacketted cylinder and an independent expansion valve riding on the back of the main valves, of which there is one at each end of the cylinder, in order to obtain the least possible amount of clearance space.

The style of design and character of workmanship are good, but the engines are invariably free from all attempt at ornamentation; neatness, strength, economy and convenience are the qualities sought by the leading firms.

The following are results obtained at the trial of engines which took place in July last, at the Oxford Agricultural Fair:

Makers' Name and Residence.	No. and diameter, cylinders.	Stroke.	H. P. Nom.	H. P. Dynamom.	Point cut-off.	Rev. per minute.	Lbs. coal per H. P. per hour.
Clayton, Shuttleworth & Co., Lincoln	1—7″	12″	4	4·42		121·65	3·73
Brown & May, Devizes	1—$7\frac{3}{16}$″	12″	4	4·19	$\frac{11}{16}$	125·65	4·44
Reading Iron Works Co., Reading	1—$5\frac{3}{4}$″	14″	4	4·16		145·7	4·65
Marshall & Sons, Gainsborough,	1—$7\frac{1}{4}$″	12″	4	4·51	$\frac{1}{4}$	124·	5·75

These were horizontal engines, attached to locomotive boilers.

The following are particulars of another set of horizontal engines of larger size, detached from their boilers, and all supplied with steam from a boiler furnished for the purpose by the managers of the show.*

These were the best engines exhibited, and the results are, of course, better than would be obtained in regular working, but they are unusually good, and even remarkable, for engines of such small size.

At a similar exhibition held at Bury, England, in 1867, considerably better results even than these were reported from engines of similar sizes and styles.

* Full particulars of these trials may be obtained by reference to the last volume of the London *Engineering*, a periodical, it may not be out of place to remark, which well represents the most advanced principles and practice of British engineering, and which is always ready to accord the credit due to American engineering.

Makers' Name and Residence	No. and diameter, cylinders.	Stroke.	H. P.		Point cut off.	Rev. per minute.	Lbs. coal per H.P. per hour.
			Nom	Dyna-mom.			
Clayton, Shuttleworth & Co., Lincoln...........................	1—10″	20″	10	11·	$\frac{3}{10}$	71·5	4·13
Reading Iron Works Co., Reading	1— $8\frac{5}{8}$″	20′	10	10·43	$\frac{1}{4}$	109·4	4·22
Marshall & Sons, Gainsborough,	1—$10\frac{3}{4}$″	16″	10	10·38	$\frac{3}{10}$	72·7	5·2

With all of these engines steam jackets were used, the feed water was highly and uniformly heated by exhaust steam, the coal was selected, finely broken and thrown on the fire with the greatest care, the velocity of the engines, the steam pressure and the amount of feed water were very carefully regulated, and all bearings were run quite loose; the engine drivers were usually expert "jockeys."

In the manufacture of larger stationary engines, British practice is in an unsettled state; the compound engine has been recently introduced where considerable power is required, but a strong tendency exists to copy from American practice.

The Corliss engine, which has been familiar to American engineers for nearly a quarter of a century, has been adopted by several builders; the Allen engine, which has been well and fully described in recent numbers of this *Journal*, is constructed by the well known Whitworth Manufacturing Company, at Manchesser. Messrs. Towle & Harding, two enterprising American engineers, are introducing the Babcock & Wilcox engine, which has been so highly commended at home for its ingenious combination of theoretical and practical requisites for economy, strength and endurance. It is to be regretted that the Greene engine, another American design, whose simplicity and effectiveness would highly recommend it in the British markets, has no one specially interested in urging its claims there.

The most usual form of stationary engine is horizontal, steam jacketted, with separate valves covering short steam ports at each end of the cylinder, and separate cut-off valves, very similar, in principle, to the Meyer expansion valve. Regulation is generally

effected by attaching the regulator to a valve in the steam pipe, but sometimes, the American idea of determining the point of cut off by the regulator is adopted. American engineers have been more successful than the British in securing small clearance, prompt closing of the cut-off valve, and in attaching the regulator to the expansion valve, while the latter exhibit a much better appreciation of the economical value of the steam jacket where high steam and great expansion are adopted. In both countries another requisite for economical practice—high piston speed—is gradually becoming fully recognized.

One of the most interesting examples in this department of transatlantic engineering is found in the engines of Messrs. A. M. Perkins & Son, of London. This firm, which was founded by an American, is guaranteeing a consumption of less than two pounds of best coal per horse-power per hour with their mill engines, and claim, in some cases, to have brought the figure as low as one pound. These engines are of a peculiar form of "compound engine," the cylinders steam jacketted and vertical, the valve stems *rotating*, with their stuffing boxes placed at the ends of long shells surrounding the stems, the intention of the arrangement being to avoid burning the packing. Surface condensers are used and the feed returned to the boiler at the boiling temperature. The steam is cut off at an early point in the stroke by an independent cut-off valve. The boilers are composed of lap welded tubes, 3 or 4 inches diameter and $\frac{3}{8}$ to $\frac{1}{2}$ inch thick, and are tested to 2500 or 3000 pounds per square inch. Where the condenser supplies an insufficient amount of feed water, the residue is furnished by a still. Steam is carried at from 250 pounds per square inch upward, the safety-valve on Messrs. Perkins' own boiler being weighted to 600 pounds per square inch.

One practice of this firm is worthy of imitation by builders generally. They insure owners of machinery supplied by them against loss by accident, and make all repairs for five per cent. per annum.

In the manufacture of stationary *boilers* the practice is not, on the whole, far different from our own. Occasionally boilers are seen with flues strengthened as described in the previous paper: now and then a boiler is met with having lap welded seams, and at least one manufacturer finds a sufficient number of intelligent patrons to afford him a market for a thoroughly well built boiler, its seams all machine rivetted, the edges of the plates neatly planed to

the proper bevel for caulking, and with all rivet holes *drilled* in place. Machine rivetting is, however, practiced by nearly all boiler makers.

The system of careful and intelligent examination pursued by the several British boiler inspection and insurance companies has done a vast amount of good, by showing that every case of boiler explosion is to be attributed to some simple cause—to faulty design, faulty material, carelessness in attendants, or to the use of badly corroded and worn out boilers. They have completely destroyed all of those far fetched theories which are so frequently proposed by believers in concealed or mysterious causes.

These companies have also been of use in assisting makers in finding a market for well designed and well built boilers, and it is be hoped that, as a similar organization has been started in the United States, equally valuable results may follow its successful operation.

In building *pumping* engines, the tendency seems to be decidedly in favor of throwing aside the cumbersome and costly Cornish engine, and adopting other forms of engine lighter, cheaper and more manageable, as well as of equal and often superior economical performance.

The favorite pumping engine, particularly in London, and where fuel is costly, seems to be a plain beam and crank engine, with a pump of the "bucket and plunger" class, and their performance will probably average 650,000 foot-pounds per pound of Welsh coal. Recently, some "*compound*" pumping engines have been built. The Berlin Water Works engine, completed some months ago by Simpson & Co., of Pimlico, is now reported to have done a duty, on trial, of 1,004,000 foot-pounds per pound of best Welsh coal, working up to 115 H. P. each, and expanding ten times. Such engines are, of course, more expensive than the former style, but their economy more than compensates for the difference in first cost, and when compared with Cornish engines, their first cost is less.

Their economy is, of course, principally due to the greater pressures and greater expansion with which they may be steadily worked. In pumping, as in marine engines, but for different reasons, a regular motion cannot well be secured with high steam and short cut off by the action of a fly wheel, and the compound engine seems to be considered the most promising resource, in this case, in the strife for highest economy of fuel.

The boilers furnished with pumping engines are usually either the single-flued Cornish or the ordinary two-flued internally fired boiler.

British machinery—with now, perhaps, the exception of marine engines—is generally characterized more by strength and durability than American, the endeavor being to obtain a substantial machine rather than one of low first cost. This difference may be probably quite as largely due to the difference in wealth and the distribution

of capital in the two countries as to a difference in the character of their engineers and mechanics.

Less ingenuity is perceived in matters of detail than in America, and we notice particularly the great lack of those little contrivances which, with us, are everywhere found contributing very largely, in the aggregate, to our comfort and convenience, to our safety, and to the economy of manual labor; but it is not unlikely that the cause of this apparent deficiency in invention may be found in an unfortunate system of patent law. In America, any mechanic who originates a useful invention readily obtains a patent, and this patent is a guarantee of his right as inventor, unless proved defective in the courts; in Great Britain, on the contrary, the cost of a patent is so great that few inventors are able to bear the expense of obtaining it and of introducing their inventions, and a patent, when obtained, has really no value as evidence of novelty. We find, therefore, invention encouraged in the United States by complete and inexpensive protection, while it is discouraged in Great Britain by the heavy expense incurred in its simple registration. The material interests of Great Britain certainly demand a change of her patent laws.

NOTE.—We are indebted to the kindness of Mr. J. Jenkinson, U. S. Consul at Glasgow, for statistics just received of the ship-building on the Clyde during the year 1870, and other valuable information. We extract the following SUMMARY of work to the close of the year:

	1868.		1869.		1870.	
	Ves'ls.	Tons.	Ves'ls.	Tons.	Ves'ls.	Tons.
War vessels	8	5,384	3	9,100	1	2,640
Paddle Steamers—						
Iron	18	6,291	11	6,500	18	9,4[illegible]0
Composite	...	......	4	1,800	2	750
Screw Steamers—						
Iron	78	78,359	88	81,800	119	132,530
Composite	4	2,882	8	3,800	2	460
Sailing Vessels—						
Iron	73	63,799	78	71,600	40	30,030
Composite	16	13,313	16	16,150	6	6,100
Wood	14	2,234	10	1,400	16	2,740
Yachts	6	331	10	750	8	450
Barges	8	1,900	10	1,000	20	3,700
Dredgers	2	485	2	100	2	1,000
	227	174,978	240	194,000	234	189,800

U. S. Naval Academy, Annapolis, Md., Jan. 21, 1871.

CORNISH ENGINES.

By W. H. G. West, U. S. N.

At this great distance from home I have had the pleasure of reading Mr. Henderson's and Mr. Birkinbine's papers, March and April, 1870, and of finding in them the final necessary evidence in favor of reasons for the superiority of the Cornish engine, advanced in my paper of October, 1868.

With the permission of the Editors, I will reply to them at the same time, and, as nearly as I can, in the order in which they are written.

I beg the readers of the *Journal* to carefully refer to the last named paper, and to that published by Mr. Henderson in the July number of 1868, so that, in reviewing the evidence already produced, there may be no doubt as to the " original question" referred to by Mr. Henderson in his last paper, March, 1870, page 159.

The *original question* was, and is, not *whether* Cornish engines did better duty than any other type of engine or not, but *why* they did it. The first and last paragraphs of Mr. Henderson's first paper, July, 1868, show it. The first and last paragraphs of my first paper, October, 1868, state it distinctly. At Mr. Henderson's request, we will return to the " original question."

Knowing well that simple argument seldom produces good effects, I have waited patiently for the time when Mr. Henderson and his supporters should make such statements as would clearly prove me correct, and that builders neglecting the principles referred to in my paper of October, 1868, could only make a good Cornish engine by accident.

My desire is, and has been, to improve the manufacture of Cornish engines in the United States, and my first paper was the offspring of that desire.

It has been observed that the " classified points of merit" set forth in Mr. Henderson's first paper are supposed to be explanatory of the causes of superiority of the Cornish engine over those of other types, but not one of these " points of merit" shows why one Cornish engine does a duty of 130,000,000, and another too far below 40,000,000 to be mentioned. What, then, causes this difference of more than 90,000,000? Not a paper written upon the subject has drawn attention to this incontrovertible fact, a fact

which goes farther to prove me correct than all that has been written.

The reasons given by Mr. Henderson—the high degree of expansion; the unfettered state of the piston; the saving of steam from loss by clearance; the isolation of the working end of the steam cylinder from the cooling influence of the condenser; the turning to direct account of the *vis viva*; the use of the steam jacket; the inelastic load—are all common to both engines, and yet one does a duty of 130,000,000, while the other does less than an ordinary high pressure engine; one of the generally acknowledged worst type.

I am especially grateful to Mr. Birkinbine for bringing this instance to light. I have been waiting for it. As he says on page 111, August, 1869, it illustrates "defects in construction." It is a Cornish engine, one of the infallibles, but owing to bad construction, and, in all probability, worse design, it is less economical than one of the worst type.

Some of the causes enumerated in my first and second papers were first observed by Mr. William West, the designer of the Fowey Consols engine, and these observations led to many of the improvements in proportions, which finally resulted in the 130,000,000 duty.

The designer of the Easton engine can, I believe, build a much better one, and can, with his own choice of attendants, make the Easton engine do better duty. He certainly would never leave the boilers out in the cold; he would never pass a palpable, or even a possible leak; he would use packing of the best quality, and lubricating matter of the proper nature and consistency; but he would never say that his engine would do better if he had not neglected some of the oldest known causes of superiority, nor would he rule out the perfectly proportioned Fowey Consols engine, because being, perhaps, heavier, it could make use of a higher grade of expansion, or because the water in his case was less elastic than in the case of the Fowey Consols engine. See elastic load, page 159, March, 1870, and page 240, April, 1870.

Elastic load has little or no effect on duty, but supposing it does account for the high duty performed by the rotative engines reported in my paper, it cannot account for the difference, in duty, between the Fowey Consols and Mr. Birkinbine's Canal Cornish engine, page 243, April, 1870, nor for a similar difference between

the Easton engine, doing 94,000,000, and the canal engine, doing too little to be reported. I have a much better right to claim that the Cornish engine does better duty because the load is *not* elastic.

Sea water is not particularly springy; indeed, it is very much like other water in that respect. The propellers of steamships work in this water, and, in the cases I have given, the propeller shafts are of about 18 inches diameter. The elasticity of sea water is no greater than that of mine water. The spring of a large propeller shaft is inappreciable, especially in fine weather, while the spring of pump rods, beams, etc, pumping through a height of 2400 feet, (Fowey Consols is somewhat deeper,) is unavoidable, and comparatively great. The moment a ship commences to spring, the engines get out of line; the journals bind and often cut; the friction is increased inversely; and—where is the advantage derived from elasticity? A stiff, unyielding ship is a blessing to the marine engineer.

Some engines lifting inelastic loads burn 8 to 10 pounds of coal per horse-power per hour, while others burn less than 2 pounds. The same thing occurs with elastic loads. All those lifting elastic loads should beat those lifting inelastic loads, but the contrary is generally the case, as shown by the Cornish engine.

Mr. Henderson finds fault with Mr. Fulton for recommending *economy in machinery*, page 153, March, 1870. He should remember that small cost does not create bad design; that it takes no more time to design an engine of good proportion than one of bad proportion, and I assure him that the Easton engine is one of the cheapest Cornish engines ever built in America.

No Cornish engines that I have ever seen, or heard of, in any country, are provided with bed-plates. The cylinders, air-pump beams aud pump work are entirely unconnected, except by the general stone foundation. No piece of iron, serving as a bed plate, reaches from one of these parts to another. Cornish engineers consider bed plates unnecessary appendages to well designed Cornish engines.

One of the highest recommendations of the Belmont engines is that brought forward by Mr. Henderson as a fault, page 153. The unnecessary outlay of money for the purchase of brass for glands, air-pump buckets, etc., is done away with. The veneering referred to by Mr. Henderson is added to the cheaper metal, for the purpose of preserving smooth surfaces, for packing, etc., to slide upon. The

water that the inhabitants of a city are to drink should not impair the strength of iron by corrosion. Pure water, without air, will not injure iron in years, even to the extent of producing a thick rust. With air it rusts bright iron very slowly. If water contains sufficient acid to corrode glands entirely separated from the water, how much more must it corrode all the pumping apparatus, pipes, valves, air pump, condenser, cylinder, etc. The whole apparatus should, therefore, be made of brass, and who would be simple enough to employ engineers who recommend such an absurdly unnecessary outlay? All this veneering may be found in the Easton engine. I do not wonder that cheap machinery is popular.

Mr. Henderson next brings forward the fact that the four foundation bolts of a 50-inch cylinder are made of $1\frac{1}{4}$-inch iron, and yet he generously sets up the productions of the designer (I do not know the name), who cannot compute the diameter of a bolt, to represent the work of American engineers before the readers of the *Journal.*

On page 154, Mr. Henderson asks why the examples given by him are not acceptable. He may read his own answer on pages 156 and 157 of March, 1870, where he says that the reports of other engineers "amount to nothing," and that "there is no limit to the artifices employed by them to carry out their designs." Almost two pages, 156 and 157, are devoted to arguments against the integrity of these gentlemen, and still he asks why his examples are not acceptable.

On page 156 Mr. Henderson says that "it is not the *custom* to estimate the duty of pumping engines by the amount of *combustible element consumed,* deducting ashes, clinkers, etc.," and, farther on, that "the whole of the coal purchased, and not seen about the works," should be charged. Mr. Henderson's *custom* needs prompt and decided reformation. On this coast I have seen bituminous coal (Welsh—the same kind as that used in Cornwall) containing less than three per cent. of refuse. I have also seen anthracite coal on this coast containing over thirty per cent. of refuse. I have seen bituminous coal, the ashes of which were burnt over and over, leaving no refuse but clinker, and I have seen scores of tons of fine anthracite which could not be burned at all in the ordinary Cornish boiler. Yet this coal was mixed with some of a better quality and sold, costing at the time of consumption about $25 per ton. Anthracite coal always contains this worthless slack. The slack of

bituminous coal is nearly as good as lump coal. Mr. Henderson's "custom" would lead us to expect as good results from a ton of miserable slaty coal as from a ton of the best bituminous.

The cost of fuel has nothing to do with duty. The price of fire wood in London is very much greater than it is in our forests, but the steaming qualities of our pitch pine are much better than those of the fire wood used in London. Coal is cheap in and near the mine from which it is taken, while it is expensive in the large city.

The custom of comparing duties without regard to quality of coal is indubitably wrong, but the amount of combustible contained shows very nearly the real value of the coal, as far as duty is concerned. The cost shows this only in a small degree; it is rather an exponent of the difficulties met with in mining, and the distance between mine and market.

Mr. Henderson lauds the Cleveland engines burning *bituminous* coal and doing 50,000,000 duty. I respectfully refer our readers to his report of the Easton engine, which shows, for it, a duty of 94,000,000, burning rather *fine anthracite* coal.

The duty done by the Cleveland engines is not good, but, on the contrary, under the average given by all the papers lately published in the *Journal.* If they had different cylinders, boilers, pumps, etc., if they were altogether different engines, they might do better duty; but these engines, as designed and erected, have done rather badly. They have done 44,000,000 less than the Easton engine, by Mr. Henderson's own showing, and yet Mr. Henderson says they are among the most economical.

It is true that, as remarked on page 157, March, 1870, the Cornish engine has "emerged triumphant" from comparisons, but I have some fear that no Cornish engines, built upon the principles which Mr. Henderson and his supporters advocate, have passed under the triumphal arch, nor do I think they will while every cause is neglected which goes to make one engine better than another of the same kind, or indeed of any kind. If they are good, why can we not get at the duties?

Why will Mr. Henderson continue to facetiously refer to the benefits derived from the upright manner in which gravity works or acts (page 158), while Mr. Birkinbine so firmly keeps the Canal Cornish engine before his eyes? It ruins his elastic argument, his gravitation argument, and indeed every other that has been advanced on his side.

I cannot accede to Mr. Henderson's request, on page 158, to produce the results of some of my favorite engines pumping water. If I have a favorite—I have no patents—it is the Cornish engine, but it must be a good one. The mails are too irregular, and I am too far from home, to gather statistics. Were I to make the attempt, it would probably be a failure, as Mr. Henderson and Mr. Birkinbine assure me that "there is no limit to the artifices," etc., page 157, March, 1870, and that "these two instances show the unreliability of some claimed duties," April, 1870.

I am perfectly willing to accept, as true, all the statistics given over the signatures of gentlemen writing for the *Journal*, but I cannot help contrasting the above quotations with Mr. Henderson's question, page 154, "why are these examples not acceptable?" and with Mr. Birkinbine's statement that his Bull engines have done 67,000,000. I would strongly urge the acceptance of a mean of all the statements, as premises on which to work.

I am given to understand that Wolf's double cylinder invention was first applied to the Cornish engine, or at least to a pumping engine built in Cornwall.

With the permission of the Editors, I will now reply to Mr. Birkinbine, in the hope that he, too, will see why some engines are wonderfully good—regardless of type or *elasticity* of *load*—while others are disgracefully bad.

Mr. Birkinbine's statements and examples have already helped me to prove that elasticity of load has nothing whatever to do with duty. Were it so favorable to rotative engines as to rule them out of comparison altogether, non-elasticity of load should put the Cornish Engine so far down as to be ruled out also. Our rotative engines were bad to begin with, they are now among the best. Our Cornish engines were very bad to begin with, they are now worse. No weighty, expansive or elastic reasons can disestablish that fact.

Mr. Birkinbine does not appear to know what "the question under discussion" is. I would inform him that it is the "original question" spoken of by Mr. Henderson, and referred to in the early part of this paper.

Mr. Birkinbine has had the misfortune to make a mistake, just a little bit funny, in putting the duties of the Fowey Consols engine Rowan's so close together on his first page. He does not appear to know that Rowan's engine was a *rotative* engine, brought forward in one of my papers to make the best Cornish engine a second rate.

in answer to a request published by Mr. Henderson in December, 1868.

The readers of the *Journal* will do well to compare the next two paragraphs (4 and 5) page 240, with the statement which Mr. Birkinbine makes in regard to the duty of his engines, 67,000,000.

In the last paragraph of page 240, Mr. Birkinbine presents my views, exactly, in regard to the reasons why pumping engines are, in many instances, bad, and it is one of the best explanations given, of the difference between duties of two Cornish engines, or, indeed, any other engines, in the proportion of 67 to 94, or to 130.

I must say of unwillingness to pay for proper machinery, that the same thing occurs in all branches of trade, but when business men order Cornish engines, (and who else does order them?) they expect to pay a fair price. Bad machinery is, as Mr. Birkinbine says, in other words, on page 240, last paragraph, the work of men deficient in engineering knowledge. The price has nothing to do with the design. The completion of a correct design costs less than a series of mistakes resulting in a failure. The Easton engine was well designed; the material employed in the manufacture was fair; the construction or execution of the design—including work of mechanics—was fair, and the *finish* was execrable. The money saved from "finish" was spent in material and good fitting. The price was very small, and the duty 94,000,000; the highest done in America by any pumping engine.

(To be continued.)

WATER WORKS FOR THE PEOPLE.

By W. M. Henderson, Hydraulic Engineer.

An abundant supply of pure and wholesome water, at an economical rate, is every where one of the first requisites of the people, and yet there are, at the present time, numbers of cities and large towns in this country where such a supply is unprovided. It is especially essential both as a beneficial sanitary measure in connection with the health, cleanliness, and comfort of a community, as well as a powerful incentive to encourage the various branches of industry to settle where this all important element is to be found. In addition to the requirements for household purposes, there are other demands, embracing mercantile necessities, as the supplying of steam boilers with water, and the numerous purposes required by factories of the different kinds; while, if the supply

will permit, there are plenty of other uses to which water may be applied with manifest advantage, as the cleansing of streets from the accumulation of offensive matter, the purification and cooling of the air, in the hot summer months, by copious distribution; also in the washing of pavements, sprinkling of streets, lawns and gardens, supplying fountains, and in many other ways contributing to the beauty and attractiveness of the city or town happily furnished with this truly health-giving medium.

As the population increases, other requirements present themselves where water is of the very utmost importance. Conflagrations will occur, more or less disastrous, frequently laying waste whole sections of cities, spreading fear, consternation and ruin on every hand, accompanied too often with fatal results.

How important, then, is this question of the abundant and reliable supply of water! And when we consider how easily this great boon can be acquired, how culpable are they who, placed in authority to administer to the wants of the people, yet neglect this most serious duty. It is not even an expensive luxury, for there is no better investment to be found for that surplus capital, existing in all thriving communities, than this producing of *water works for the people*. They are at once a source of revenue, being self-maintaining by the collections arising from water rents, fully adequate, by proper management, to pay a liberal interest upon the investment, and to rapidly create a sinking fund to pay off the original outlay. Apart from all this, they will be found to repay many times their cost, in the matter of reduction of insurance rates, and the saving effected in regard to property, which would otherwise have been destroyed. They also enhance the value of this property, as has been found to be the invariable case wherever they have been introduced.

The primary step to be taken, when it has been decided to have water introduced into a town, is to ascertain, by a general survey of the immediate neighborhood, whence a quantity, adequate to the necessities of the inhabitants, can be procured. It should be determined beyond doubt that this source shall be amply sufficient to furnish, at all times, the amount absolutely required, even in seasons of drought—for once the people have been led to depend upon a regular supply the former means will have been abandoned, passed away and beyond the reach of being again made servicable. These preliminaries having been satisfactorily settled upon, the question of preference in regard to the system to be adopted for distributing the supply, is purely one of a pecuniary character. The various plans upon which water works have been successfully constructed, will be found to be embraced under the following heads:—

Water Supply with Reservoir—Water Supply with Standpipe—and Direct Water Supply.

1*st. Water Supply with Reservoir.*

This is the oldest of the methods here described for supplying cities with water, and for many reasons it is the best; at the same time it is the most expensive. But where enconomy of first cost is not considered the paramount object to be obtained, it will be found to be the cheapest in the end. The manifest advantage of the reservoir system is to be found in the storing up of a large body of water, to be made available in time of drought, or in case of interruption by accident to any part of the pumping machinery. The reservoir maintains a constant head upon the mains, by virtue of simple hydrostatic pressure. And it also serves as a repository for any impurities the water may hold in suspension, which settle to the bottom, the pure water being withdrawn from a few feet above. Another great advantage of the reservoir is, that the pumping can be effected within certain limits of time—say half time running; thus affording ample opportunity for keeping the machinery in proper working order, as well as giving the engineer in charge facilities for a general inspection of the works, with a view to repairs, or contemplated additions and improvements.

The proper carrying out the benefits to be derived from this system necessitates the use of a distinct distributing main, though it not unfrequently happens the delivery main from the pump is made to serve the double purpose. The value of the reservoir system was fully exemplified to the citizens of Philadelphia during the drought of 1869. Had it not been for the *Reservoirs*, the suf fering of the people must have been calamitous.

2*d. Water Supply with Standpipe.*

This in order is the next method for maintaining a uniform pressure upon the street mains. The water from the pump rises within the standpipe to an elevation corresponding, in effect, the same as if a reservoir of a similar altitude were employed. The irregularities produced by the action of the pumps are here equalized, and the stream caused to flow in a steady current. It is apparent the quantity of water capable of being contained in the standpipe is a very limited amount, consequently no prolonged stoppage of the machinery can be indulged in, although it will afford sufficient time for repacking the engines, and other ordinary adjustments. Some of the water works in and around Philadelphia, have, in times past, supplied their water by the aid of the stand pipe, varying from 130 to 170 feet in height. At Erie, Pa., there is one of 217 feet high—said to be the highest in the world. As an expedient to overcome the expense attending the building of a reservoir, the stand pipe has been found to answer remarkably well.

Of course the water will be delivered with all the [illegible] hold in suspension, but if the water to be pumped [illegible] in a subsidiary reservoir, filter bed or [illegible] according to the plans usually pursued in [illegible] without doubt, be furnished of a pure and wholesome [illegible].

The proper carrying out of this system involves [illegible] duplicate machinery and double set of hands [illegible] water, for it would be impossible to guarantee a single pumping engine against accidental derangement at some time which would be fatal, as will be readily perceived.

3d. Direct Water Supply without Reservoir or Standpipe.

The idea of dispensing with all auxiliary receptacles for retaining any mass of water, and pumping directly through the mains to the consumers, was, it is believed, first introduced in London, in the year 1582, where was erected, at London Bridge, a water wheel, driving four gang piston pumps, arranged to take water alternately, which at that time created quite a sensation. The machinery, it is related, was found, upon trial, to be very effective, furnishing a good supply of water to the city, and had the capacity of throwing streams of water over St. Magnus steeple. The growing wants of the city, impurity of the water, and other reasons, combined to its abandonment fully a century ago. Quite lately this identical system has been reproduced in this country, the firm now building upon this plan claiming to have originated it, and lauding it above every thing else for water work purposes. In addition to the gang pumps, the American inventor has introduced the extraordinary combination of *rotary pumps*, and where steam is to be substituted for water power, *rotary engines* also—two of the most wasteful forms, for the purpose, which the ingenuity of man could well devise. There are many situations and attending circumstances where the direct supply system can be employed with advantage. But that is the *ne plus ultra*, for all and every rotation is a plain misrepresentation of facts. That which immediately recommends it is the comparatively small outlay required to erect works upon this plan. A standpipe or reservoir can afterwards be added, when the necessary capital has been raised. It is not imperatively necessary, however, to employ a gang of small pumps, interspersed, by way of variety, with one or more upon the *rotary principle*; nor is it likely to be conducive to economy to employ, as a motor, a steam fan, or, as it is commonly called, a *rotary engine*, to produce the simple results aimed at. Indeed there is little occasion to depart from the usual description of machinery, perfected by long usage to the requirements of water work purposes. The all-absorbing question of economy in regard to fuel and repairs, is a powerful argument against the *rapid reciprocation* of short stroke gang pumps, and the ruinous effects produced by that *high velocity* demanded by the rotary principle. Economy in any form, under such circumstances, is entirely out of

the question; for so long as the laws which govern the universe are in force, that which was established at one period of time will still remain a fact in all succeeding ages, and no amount of controversy, or opinions of any set of men, advanced as a species of special advocacy, have the power of setting it aside. *The true expense of an engine is the original price, added to its annual cost for maintainance, capitalized say at 20 years' purchase.* The direct supply system dispenses with the cost of constructing reservoirs, to which extent it will be more economical in the first instance. But it is less regular than either of the others. The machinery is required to be kept in motion all the time, or at least ready to start at any moment when water is wanted. Vigilance is an incessant and arbitrary requirement. A fire may break out any instant of time, night or day, and may not occur for months; still the price of security is eternal vigilance, which in the case where steam is employed as a motive power, means continuous consumption of fuel; which again, in plain English, means wasting money. In connection with this system, it must not be forgotten that all the connections pertaining to the distributing mains require to be made especially heavy, and consequently more than usually expensive, with a view to withstand the excessive pressures thrown upon them when the engines are forcing against the enormous pressure necessary to be effectual in case of *fire.* It becomes quite a serious question, then, whether it is altogether satisfactory or judicious to assume this extra cost, together with the risk of leaking joints and bursting pipes, from the cause pointed out, for the mere sake of dispensing with that portable fire apparatus so well known throughout the country.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 109.)

Friction Wheels.—" Wheels acting upon each other are the instruments by which the transmission of force from one part of a system of machinery to another is commonly and conveniently effected. The due connection of the moving parts is accomplished either by the mutual action of properly formed teeth, by straps or endless bands, or by the friction of one face of a wheel against another. The latter method has, when, adopted, been generally in small light works, where the pressure upon the different parts of the machinery is never considerable. Nr. Nicholson saw a drawing

of a spinning wheel for children, at a charity school, where a large horizontal wheel, with a slip of buff leather glued on its upper surface, near the outer edge, drove 12 spindles, at which the same number of children sat. The spindles had each a small roller, likewise faced with leather, and were capable, by an easy and instantaneous motion, of being thrown into contact with the large wheel at pleasure. The winding bobbins for yarns at the cotton mills operate on the same simple and elegant principle, which possesses the advantage of drawing the thread with an equal velocity, whatever may be the quantity on the bobbin, and cannot break it.

"We are not aware that the same mode of communication has been adopted in large works, except in a saw mill, by Mr. Taylor, of Southampton. In this the wheels act upon each other by the contact of the end grain of wood instead of cogs. The whole makes very little noise, and wears very well; it has now been in use nearly twenty years. There is, of consequence, a contrivance to make the wheels bear firmly against each other, by wedges at the sockets, or by levers. This principle and method of transmitting power certainly deserves every attention; particularly as the customary mode, by means of teeth, requires much skill and care in the execution, and, after all, wants frequent repairs."—*Treatise on Mechanics. Olinthus Gregory: London*, 1806.

From *Rankine's Manual of Machinery and Mill Work* we take the following:

"The flexible pieces used in machinery may be classed under three heads: *Cords*, which approximate to a round form in section; *Belts*, which are flat; and *Chains*, which consist of a series of rigid links, so connected together that the chain, as a whole, is flexible. Mr. Willis gives them all the common name of *wrapping connectors*; and for the sake of brevity in stating principles that apply to them all, they may conveniently be called *bands*.

"The *effective radius* of a pulley is equal to the radius of the pulley added to half the thickness of the band.

"Smooth bands, such as belts and cords, are not suited to communicate a velocity-ratio *with precision*, as teeth are, because of their being free to slip on the pulleys; but the freedom to slip is advantageous in swift and powerful machinery, because of its preventing the shocks which take place when mechanism which is at rest is suddenly *thrown into gear*, or put in connection with the prime mover. A band at a certain tension is not capable of exerting more

than a certain definite force upon a pulley over which it passes, and therefore occupies, in communicating its own speed to the rim of that pulley, a certain definite time, depending on the masses that are set in motion along with the pulley and the speed to be impressed upon them, and until that time has elapsed the band has a slipping motion on the pulley; thus avoiding shocks, which consist in the too rapid communication of changes of speed.

"The swell usually allowed in the rims of pulleys is *one twenty-fourth part of the breadth.*

In quarter twist belts, "in order that the belt may remain on the pulleys, *the central plane of each pulley must pass through the point of delivery of the other pulley.* It is easy to see that this arrangement does not admit of reversed motion.

"The safe working tension of leather belts, according to Morin, is 285 pounds on the square inch. The ordinary thickness of belting leather is about ·16-inch.

"The inside of the leather is rougher than the outside, and is placed next the pulleys, crossed belts being twisted so as to bring the same side of the leather in contact with both pulleys.

"*Leather belts*, when new, are not quite of the heaviness of water, say 60 pounds per cubic foot; but after having been for some time in use, they become thinner and denser by compression, and are then about as heavy as water. The weight of single belting is approximately ·068 pounds per one inch breadth and one foot length.

"*Raw Hide Belts* have a tenacity about one and a half that of tanned leather. When raw hide is used for belts or for ropes it is soaked with grease, to keep it pliable and protect it against the action of air and moisture.

"*Gutta-Percha* is sometimes used for flat belts. They are made of the same dimensions with leather belts for transmitting the same force, and are nearly of the same weight.

"*Woven Belts* are made of a flaxen or cotton fabric, a sufficient number of plies being used to give a thickness equal to that of leather belts, and cemented together with india rubber. When made of flax, they are said to be about three times more tenacious than tanned leather belts of the same transverse dimensions.

"Ultimate tenacity of leather rope, 10,000 feet, or 3360 pounds on the circular inch; of raw hide, 15,000 feet and 5040 pounds on the circular inch; safe working tension, one-sixth of these dimensions.

"The ordinary speed of wire ropes in Mr. C. F. Hirn's 'Telodynamic Transmission' of power is from 50 to 70 feet per second; and with wrought iron pulleys it is considered that the speed may be increased to 100 feet per second.

"In order that the rope may not be overstrained by the bending of the wires of which it consists, in passing round the driving and following pulleys, the diameter of each of those pulleys should not be less than 140 times the diameter of the rope, and is sometimes as much as 260 times.

"The distance between the driving and following pulleys is not made less than about 100 feet; for at less distances shafting is more efficient; nor is it made more than 500 feet in one span, because of the great length of the catenary curves in which the rope hangs. When the distance between the driving and following pulleys exceeds 500 feet, the rope is supported at intermediate points by pairs of bearing pulleys, so as to divide the whole distance into intervals of 500 feet, or less.

"The bearing pulleys have half the diameter, and are of similar construction with the driving pulleys.

"The loss of work due to the stiffness of the rope may be regarded as insensible; because, when the diameters of the pulleys are sufficient, the wires of which the rope is made straighten themselves by their own elasticity, after having been bent.

"Experience shows the loss of power by the axle friction of driving and following pulleys to be about $\frac{1}{30}$th, and of the axle friction of each pair of bearing pulleys about $\frac{1}{500}$th of the whole power transmitted."

(To be continued.)

ON THE HORSE-POWER OF STEAM ENGINES AND BOILERS, AND SOME FACTS CONNECTED WITH THE EXPANSION OF STEAM.

By Edward Brown.

[Read before the Franklin Institute at its Stated Meeting in January.]

An actual horse-power, as is well known, is 33,000 pounds raised one foot high per minute. The application of this test to engines and boilers is the subject of this paper.

It has been, and still is, a common custom with steam engine builders, to specify in the contract of sale that the engine and boiler are of a certain size and horse-power. That the machines come up

to the contract in size is easily determined by measurement, but the actual horse-power developed by a steam boiler is a subject upon which the seller and buyer may differ materially.

It is useless for one to attempt to make a standard rule for the horse-power of an engine from the size of the cylinder. An engine 10 × 24 inches will work from 20 to 100 horse-power, according to the pressure of steam and speed of the piston. The seller might designate whatever power he pleased within these limits; it would be very little guide to the purchaser.

The case is, however, different when we come to estimate the horse-power of an engine and boiler sold as a unit. There will be no question among engineers that here the horse-power, according to common custom and practice, is the power exerted upon the piston, measured by the area of the indicator diagram. If the machine will perform that work steadily, from week to week, such is its actual horse-power.

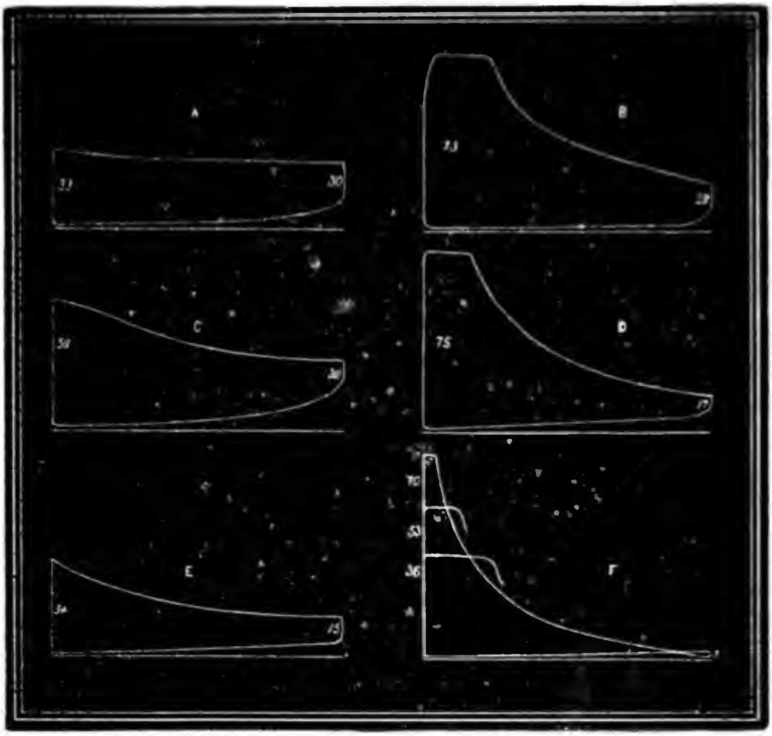
Let us now examine the means of ascertaining the horse-power of a *steam boiler*, sold, we will say, for 100 horse-power, but failing to come up to the expectation of the purchaser. This is a practical question, and one not unfrequently occurring. Especially is it liable to occur with boilers of the non-explosive patterns, recently introduced. The makers are endeavoring to supply, and the purchasers to obtain, a perfectly safe boiler, of the same horse-power and at the same price as those of the usual standard forms.

Several cases of this character having recently come under my observation, I will give you the course pursued in one of them to ascertain the horse-power of the boiler.

The boilers replaced some old worn out boilers which were removed. They supplied steam to a cylinder 16 inches by 4 feet, speeded for about fifty revolutions. The boilers were fired to the best ability of the fireman, and steam being maintained at forty revolutions, the cards A were taken, showing no expansion and $55\frac{1}{2}$ H. P. It was justly objected by the Boiler Company that this was an extravagant use of the steam, and not a fair test of the H. P. of the boiler. A Tremper cut-off was then fixed on the back of the steam chest, and a trial made a few days afterwards. The steam chest was small, and the space between the cut-off and D valve not over one-tenth the size of the cylinder. The card marked B was then taken showing a cut-off at a little under $\frac{1}{4}$ from the commencement of the stroke, and 68 H. P. with 33 revolutions. It is

a very fair expansion card, the [illegible] Though not quite equal to a Corliss, it would [illegible] economy. The gain in power resulting from the change from full stroke to ⅓ cut off is 12½ horse, or 23 per cent. due to expansion of the steam. But as there was [illegible] less than in the former trial, we have an actual gain of 30 per cent. in the working of the engine. The engine exhausted into a feed water heater.

Now notice the diagram C. This was taken with more [illegible] power, 3 being used instead of 2, as in the trial just described. The expansion curve here is formed entirely by the higher speed of the



engine (53 revolutions) and the smallness of the port. The indicated H. P. was 89, and that developed by the Tremper cut-off, marked D, was 100 H. P. Here we have a gain of 12 per cent. only, due to the cut-off and expansion thereby: and a gain of 20 per cent. in the working of the engine. 12 per cent. from 23 per cent. leaves

11 per cent. gain, due to the wire drawing of the steam, as in card C, over that used in the first trial, as shown by card A.

This result tends to prove that it matters little in practice whether the *expansion curve is formed* by the wire drawing through the port and the speed of the piston, or in the usual cut-off manner and low speed; and for this reason, that the action of the steam after it passes the port is almost instantaneous in comparison with the motion of the piston. The cylinder was well curved, though the steam pipe was not; had it been covered, and the cut-off valves close at each end of the cylinder, a little better result would have been obtained. The gain of 23 per cent. here obtained corresponds closely with the experiments of Mr. Isherwood, who gives 26 per cent. as the gain by suppressing during the last $\frac{3}{4}$ of the stroke, and using saturated steam. His experiments also go to show that about 16 out of this 26 per cent. is gained by suppressing during the last $\frac{1}{4}$ of the stroke.

When we consider the vast disproportion between the power which should be gained by cutting off at $\frac{1}{4}$ stroke, theoretically, and that resulting from practice, we may well doubt, as some engineers have done, if there is any gain in the expansion of steam *per se;* and conclude that the gain is due more to the application of the power at the commencement of the stroke, and the complete utilization of it before the termination. An experiment dispelled this supposition. During the dinner hour, when the engine was running the shafting only, the work being therefore constant, diagrams were taken at a speed of 48 revolutions. Four were taken at full stroke, marked E, and three were taken at short cut-off, as shown at F; the average pressure of cards E was 16·3 pounds, and of cards F 16·4 pounds, sufficiently near to be called identically the same. The experiment was carefully made, with the indicator just cleaned and oiled, and the calculated power was 38 H. P. In theory, a pressure of 50 pounds through any part of the stroke would be as effectual as the same pressure through any other part of the stroke, taking no account of momentum. If we take this into consideration, the natural conclusion would be that a preponderating power at the commencement of the stroke, or, in other words, the proper application of the power at the right time, would be more effectual than an even power continued at the end of the stroke. Consequently, the cut-off cards should be smaller, but such was not the case; clearly showing that the gain in power in the previous trials was due to expansion. Of course, the equality of the two cards, E and

P., only refers to the particular engine [illegible] the experiment was made at [illegible] revolutions [illegible] off cards would be found the [illegible]. In a [illegible] the indicator should be changed to each end of the cylinder [illegible] of it in the centre, though frequently adopted [illegible] is not sufficiently accurate.

The bearing these facts have upon the question before us is this—that whilst the horse power of a boiler depends somewhat upon the engine it supplies, still it is only to a limited extent. That a 3 port D valve engine, in good order, and cutting off at less than [illegible] from the termination of the stroke, is realizing within 12 per cent. of the power. And even granting that it may be 20 per cent. under what is obtained in the best cut off engines, a boiler should be able to give out that amount extra in a trial of ten hours, with good coal and careful firing.

Again, purchasers of steam boilers look at the question in a practical way; they do not understand the fine point, as to how much power the evaporation of so much water should produce; they want the power put through their own engine, and as three-quarters of all the steam engines in use are plain slide valve, it is but reasonable to expect that every boiler sold for a certain H. P. shall be able to put that power through a plain slide valve engine, of proper capacity, in good order, and suppressing steam more than ¼ of the stroke.

Let us now consider the test by the evaporation of water. A 100-horse boiler may be sold to supply a 50-horse engine, the other 50-horse being required for heating purposes: or the boiler may be needed entirely for heating purposes. Here we must decide by the evaporation, and if the purchaser has not had the foresight to specify the amount, what shall be the test?

We take the old *nominal* H. P., and the evaporation of 1 cubic foot of water is the test. We come down to the theoretical H. P., and 920 inches or 33 pounds is the test. That is to say: theoretically, if you have a cylinder 1 square foot area and 1728 feet high, and evaporate 1 cubic foot of water within that cylinder, in an hour and then condense the steam, it will give a force of 1·88 H. P.

I find on reference to Mr. Isherwood's experiments, that he obtained, occasionally, 1 H. P. from the evaporation of 29 pounds of water, 4 pounds less than the theoretical amount: this can only be accomplished by expansion. With superheated steam he obtained

1 H. P. from 20 pounds of water and an early cut-off. Modern practice has done better than this with the compound engine.

On the other hand, the steam may be overcharged with watery particles, and so show a high evaporation with little power; I have seen $\frac{9}{10}$ths of a cubic foot required to produce a H. P. in a very fair engine, cutting off at the last quarter. So we see that the range is from less than half a cubic foot to $\frac{9}{10}$ths of a foot; the average for good engines being about 40 pounds. It is quite safe to assume that the evaporation of 1 foot of water is abundance for a horse-power, provided the consumption of coal be taken into account; for a small boiler with good draught, burning much coal, will give out as much power as a larger boiler burning less coal. Therefore, the commercial value of a steam boiler, estimated by the H. P., depends upon its ability to evaporate a given amount of water into DRY steam, on a basis of a certain amount of coal, say, about 8 pounds. The conclusion arrived at in reference to this subject would be, that neither the test by the engine nor by evaporation is a positive test. By the engine test, the efficiency of the engine is always liable to be called in question. The steam pipe may be long and contracted, and the pipe and cylinder uncovered, and a large back pressure, for which allowance must be made. The boiler may also be forced for a trial of ten hours, and more coal burnt than usual.

And by the evaporation test it will be found that some boilers are notorious for lifting water; that is, carrying it over bodily. Exceptional cases will always occur in which either test is unsatisfactory; then the only way is to combine the two methods.

It is desirable that the Franklin Institute should establish some standard generally acceptable among engine builders, so that the mill owner, in the purchase of a boiler of a certain H. P., may expect a definite quantity.

Until such is established, it will be for the interest of makers and purchasers of steam power to specify the test by which the power is to be measured.

ON TILGHMAN'S PROCESS OF CUTTING HARD SUBSTANCES.

By Coleman Sellers.

How to cut or carve, mechanically, hard substances, such as stone, glass or hard metals, in an expeditious, accurate and economical manner, has always engaged the attention of engineers. At the present time, the rapidly increasing cost of manual labor makes improvements in this direction more needful. The discovery and utilization of opaque crystallized carbon, cheaper than transparent diamonds, but perhaps equally durable, has gone far in this direction. Now, Mr. B. C. Tilghman, of Philadelphia, comes forward, and shows that a jet of quartz sand thrown against a block of solid corundum will bore a hole through it 1½ inches in diameter, 1½ deep, in 25 minutes, and this with a velocity obtainable, by the use of steam as the propelling power, at a pressure of 300 pounds per square inch—a remarkable result, when we consider that corundum is next to and but little inferior to the diamond in hardness.

At the stated meeting of the Franklin Institute, held February 15th, 1871, the Resident Secretary, Dr. W. H. Wahl, introduced this invention, illustrating his description of it by practically cutting or depolishing the surface of a plate of glass by a sand blast of very moderate intensity. Various examples of hard substances cut, depolished and carved into shape, were displayed. In the discussion which followed the presentation of this very remarkable discovery, Mr. Robert Briggs, in his interesting remarks on the subject, took occasion to say that it had been long remarked that window glass, exposed to the wind driven sand, near the sea shore, soon loses its polish, and cited some other well known examples of the erosion of surface when exposed to a continued stream of moving particles. When we think of the many such examples, and consider that engineers have had continually to make provision against this well known cutting effect, it seems surprising that it should not have been turned to some good account before this.

Mr. Tilghman's attention seems first to have been directed towards cutting stone, or hard metal, by a jet of sand impelled by escaping steam under high pressure. His early experiments were, I believe, with very high pressure, but as he progressed in the knowledge of results obtainable with various velocities, a great use for this process seemed to develop itself in sand driven by moderate air blasts,

and applied to grinding or depolishing glass for ornamental purposes.

For grinding glass he uses a common rotary fan, 30 inches in diameter, making about 1500 revolutions per minute, which gives a blast of air of the pressure of about 4 inches of water, through a vertical tube, 2 feet high by 60 inches long, and 1 inch wide.

Into the top of this tube the sand is fed, and falling into the air current and acquiring velocity from it, is dashed down against the sheets of glass, which are slowly moved across, about 1 inch below the end of the tube. About 10 or 15 seconds exposure to the sand blast is sufficient to completely grind or depolish the surface of ordinary glass; so that sheets of it carried on endless belts may be passed under this 1-inch wide sand shower at the rate of 5 inches forward movement per minute. In the machine in use for this purpose the spent sand is reconveyed to the upper hopper by elevators, and the dust made by the sand blast (which might otherwise be a source of annoyance to the workmen) is drawn back into the fan, and thence passes with the wind into the blast ton, and again mingles with the shower of sand upon the glass.

By covering parts of the glass surface by a stencil or pattern of any tough or elastic material, such as paper, lace, caoutchouc, or oil paint, designs of any kind may be engraved.

There is a kind of colored glass made by having a thin stratum of colored glass melted or "flashed" on one side of an ordinary sheet of clear glass. If a stencil of sufficient toughness is placed on the colored side, and exposed to the sand blast, the pattern can be cut through the colored stratum in from about 4 to 20 minutes, according to its thickness.

The theoretical velocity of a current of air of the pressure of 4 inches of water, he calculates, is (neglecting friction) about 135 feet per second; the actual velocity of the sand is doubtless much less.

If a current of air of less velocity is used, say about 1 inch of water, very delicate materials, such as the green leaves of the fern, will resist a stream of fine sand long enough to allow their outlines to be engraved on glass. By graduating the time of exposure with sufficient nicety, so as to allow the thin parts of the leaves to be partly cut through by the sand, while the thicker central ribs and their branches still resist, the effect of a shaded engraving may be produced.

The grinding of such a hard substance as glass by an agent which

is resisted by such a fragile material [illegible] rather singular. The probable [illegible] sand which strikes with its [illegible] infinitesimal portion which [illegible] which strike the leaf rebound from it [illegible]

The film of bichromatized gelatin, used as a photographic negative, may be sufficiently thick to allow a picture to be engraved on glass by fine sand, driven by a gentle blast of air.

For cutting stone the inventor uses steam as the impelling jet; the higher the pressure, the greater is the velocity imparted to the sand, and the more rapid its cutting effect.

In using steam of about 100 pounds pressure, the sand is introduced by a central iron tube, about $\frac{3}{16}$-inch bore, while the steam is made to issue from an annular passage surrounding the sand tube.

A certain amount of suction of air is thus produced, which draws the sand through the sand tube into the steam jet, and both are then driven together through a tube about 6 inches long, in which the steam imparts its velocity to the sand, and finally strike on the stone, which is held about an inch distant from the end of tube.

At the spot struck a red light is visible, as if the stone was red hot, though really it is below 212° Fah. The light is probably caused by the breaking up of the crystals of the sand and stone.

The cutting effect is greatest when free escape is allowed for the spent sand and steam. In making a hole of diameter but slightly greater than that of the steam jet, the rebounding steam and sand greatly interfere with and lessen the efficiency of the jet.

Under favorable conditions, using steam which he estimated as equal to about 1½ horse-power, at a pressure of about 125 pounds, the cutting effect per minute was about 1½ cubic inches of granite, or 3 cubic inches of marble, or 10 cubic inches of soft brown sand stone.

By means of flexible or jointed connecting tubes, the blast pipe is made movable in any direction; grooves and mouldings of almost any shape can thus be made, or by means of stencil plates, letters or ornaments can be cut either in relief or intaglio, with great rapidity in the hardest stone.

At a high velocity, quartz sand will cut substances much harder than itself, as before stated. With a steam jet of 300 pounds pressure, a hole 1½ inches in diameter was cut through a piece of corundum, 1½ inch thick, in 25 minutes.

A hole 1 inch long and $\frac{1}{4}$ inch wide was cut through a hard steel file $\frac{1}{4}$ inch thick, in 10 minutes, with a jet of 100 pounds steam.

A stream of small lead shot, driven by 50 pounds steam, wore a small hole in a piece of hard quartz ; the shot were found to be only very slightly flattened by the blow, showing their velocity to have been moderate.

Among the curious examples of glass cut by this sand blast was shown a piece of ordinary window glass, which, having been partially protected by a covering of wire gauze, had been cut entirely through, thus producing a glass sieve, with openings of about $\frac{1}{12}$th of an inch, the intervening glass meshes being only $\frac{1}{16}$th of an inch wide. This seems to have been produced more as a curiosity than for any practical purpose. Should such a sheet of perforated glass be required, it is questionable if it could be produced for a solid sheet by any other method.

A microscopic examination of the sheet glass depolished by this process shows a succession of pits formed by the blows of the impinging grains of sand, and looks more uniform than do surfaces ground by any rubbing process.

This steam sand jet has already been introduced to clean cast iron hollow ware previous to tinning the interior. Heretofore the interior surface has been turned, it having been found necessary to remove a thin shaving in a lathe to obtain a clean surface. The surface is cleaned more rapidly by the sand blast, and even more perfectly, because it penetrates into any holes or depressions which the turning tool could not reach. It is also probable that the sand striking the particles of plumbago, which separate the particles of metallic iron in ordinary gray cast iron, will remove them, and thus expose a continuous metallic surface to take the tin.

In this relation I might note, that about twenty-five years ago, some experiments were made in Cincinnati, at the establishment of Mr. Miles Greenwood, by my brother, Mr. George Escol Sellers, with a view to making tinned hollow ware of ordinary gray iron. He made a machine for scouring the inside of the pots and kettles with sand and water; afterwards the still wet, scoured surfaces passed into the chloride of zinc solution, and thence into the molten metal, and were uniformly turned. For some reason, the process was not continued, and now it is only recorded as an abandoned invention, never before made public. The wet sand grinding could

not, in this case, have been so efficient as Mr. Tilghman's sand blast. To speculate on the various uses to which this process may be applied, would not serve any good end, and would take up too much space. With this discovery we can hardly help recurring to the works of the ancients, and wondering if some such process could have aided the workers in the stone age, or could have been used in carving the Egyptian hyeroglyphics. It has been noted by those familiar with the cutting or dressing of stone, that some materials, such as granite, is very much injured, or "stunned," by the blows of the cutting tool, and after being hand dressed a thickness of perhaps from $\frac{1}{8}$th inch to $\frac{1}{4}$th inch has to be ground away, to produce a solid uniform surface. By this sand cutting process the surface is not injured, is not "stunned," and is ready for polishing at once.

One curious fact connected with its use is, that when a surface to be cut in intaglio or otherwise is partially protected by templates of metal, these templates curl up under the blows of the sand, so that paper patterns are really more durable than patterns cut from brass. Sheet steel, cut into shape and then hardened, will also curl up under the blows of the fine particles of sand, unless protected by sheets of yielding material. Fine lace will protect glass during the depolishing process, and leave its designs in polished lines on a ground surface.

Artificial Production of Indigo.—In former numbers of this *Journal* we recorded a triumphant achievement for organic chemistry, in the manufacture of alizarine, the coloring principle of the madder root; to this we may now add another, no less in importance than the artificial production of the Indigo blue. The glimpse we are permitted at the dormant possibilities of this marvellously active science, by the two brilliant discoveries so recently made, and here referred to, is perplexing in its infinite variety. In a commercial sense, the discovery is as yet valueless, no time having elapsed for its development with this object in view: but it is too manifestly a mere question of time to need remark. This important discovery is the fruit of the labors of two German chemists, Messrs. Emmerling and Engler. The process of manufacture is a highly complicated one, and altogether of too technical a nature to be here reproduced. The announcement, however, of the fact cannot fail to awake the liveliest interest.

Mechanics, Physics, and Chemistry.

THE SUN.

(A course of five lectures before the Peabody Institute of Baltimore, January, 1870.)

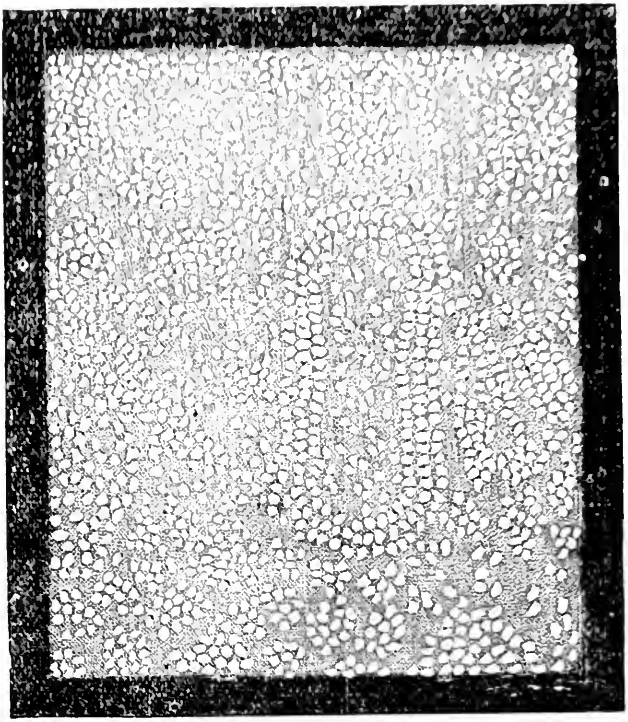
By B. A. Gould.

(Continued from page 137.)

The granules are of various sizes, but may, on the average, be roughly taken as about $1\frac{1}{2}''$ in length and $1''$ in breadth, corresponding to about 675 by 450 miles. As seen with a magnifying power of 100 diameters, they may fairly be compared to rice grains, but under higher powers their regularity of form mostly disappears. Some are nearly round, others oval, and others still almost without symmetry of outline. On many parts of the sun they are separated by small dark intervals; except in the penumbra of spots they are rarely superposed; but in many places they are closely aggregated, and give the effect of bright tesselation. These *groups* of aggregated granules are often round or oval, and have unquestionably been often mistaken for single ones. The coarser mottling of the solar disk arises chiefly from the alternation of lines or groups of closely aggregated granules, and of regions in which they are less abundant. The points are the interstices between them, as they appear through a telescope of insufficient power. In a faculæ the granules are aggregated very compactly, while in the penumbra of a spot they are smaller and fainter, although superposed sometimes quite thickly one upon another. Mr. Huggins sums up most admirably, by saying: "The phenomenon would be well represented if we might suppose that the granules are recently condensed incandescent clouds; that they slowly sink, merge into each other, become less and less luminous, and gradually dissipate into comparatively non-luminous gas. The dark pores would then be represented by the portions where complete vaporization had taken place." He also gives an interesting diagram, which is here reproduced, to show the distribution of the bright granules on those parts of the sun which are free from spots, in some of the most characteristic forms of their grouping. There is also some reason to suspect that all the granules may not be of the same brilliancy, although those in any one group closely resemble each other.

Thus it seems established that the luminous surface of the sun is entirely composed of these glowing particles or granules, almost as small as we can discern, notwithstanding that they can scarcely be less than 700 miles in length, floating in a sea of darker, though

Fig. 7.



luminous matter. The brighter and the darker mottlings of the ordinary surface, the brilliant glow of the faculæ, and the dimmed lustre of the penumbra must alike be referred to the intrinsic splendor of individual granules, distributed in different ways, arranged more or less compactly and at different degrees of submergence in the fluid medium which supports them. And Lockyer, a young English astronomer, who has done much within the last three or four years to advance our knowledge of the constitution of the sun, says * that he has seen the granules in the penumbra change their axial direction, and others, visible against the nucleus as a background, gradually melt away. Chacornac, a French observer of distinction, says, moreover, that the granules, or crystals, as he calls them, may be seen dissolving like crystals of sugar before a jet of steam: be-

* *Monthly Notices R. Astr. Soc.* XXV, 237.

coming spotted over with dark points before they finally disappear.

We have thus arrived at the present condition of our knowledge regarding the structure of the incandescent outer surface of the sun, a matter of the greatest moment for the formation of any trustworthy opinions regarding the real nature of the spots or faculæ. We must now return to the spots, and consider the knowledge thus far obtained concerning their motions, real or apparent.

The apparent time of the sun's rotation, as indicated by the motion of the spots, was determined with very tolerable accuracy by the early observers, and Scheiner, in 1626, deduced the position of the axis with close approximation to the truth. Were it certain that the spots were fixed immovably upon the sun, the time of their revolution would clearly be the same as that of the sun's rotation; but this assumption, which was never justifiable, is now known to be incorrect. Then, there is another matter to be borne in mind, viz., that the apparent line of rotation is not the real one; for, since the earth is moving round the sun in the same direction in which he is turning on his axis, a longer period than the true time of rotation must elapse before the rotation would appear complete to an observer on the earth. For example, if a point on the sun appeared to rotate in 28 days, or about the thirteenth part of a year, the earth, our own place of observation, would, during that time, have moved through the thirteenth part of her annual orbit, so that these 28 days would exceed the true time by its thirteenth part, and this true time would be only about 26 days. This last source of error is easily allowed for, but in the former case it is not so. For, if the spots are not stationary upon the sun's surface, we have absolutely no visible fixed point of reference, and are left without landmarks. In fact, such is really the case, and our only means of measuring the period of rotation gives, not that of the sun, but that of some spot which is not fixed. Langier discovered,* in 1846, what abundant observation since then has confirmed, that the periods deduced from different spots are not accordant, although the range of their variation is comparatively small. The most natural course, under the circumstances, is to deduce the period of rotation from as many spots as possible, and to assume that their average represents that of the sun; yet it might well be that all of them have a motion parallel to the sun's equator, and in the same direction, in which case we should be measuring not the period of rota-

* *Comptes Rendus de l'Acad. des Sciences*, 1842, II, 940.

tion, but that of a rotation increased or diminished by the average motion of the spots meanwhile. This is, however, the best that we can do, and all our results are subject to this criticism. We have reason to believe that there is in fact little, if any, error from this source, still the question as to currents at the sun's surface thus acquires a double importance. Carrington, of London, devoted seven and a half years, from 1853 to 1861, to daily observation of the position of solar spots. He thus collected 5290 distinct observations, from which it became clearly manifest that the time of rotation of any spot depends upon its latitude upon the sun.* He deduced a formula to express the relation, and this, after correction by Faye, proves to be a very simple one.† It represents the various observations within the limits of their probable errors, and, taken in connection with the small motion of the spots in latitude, discloses the additional fact that any solar currents which exist must be far from powerful; at the same time it raises new and interesting questions as to the agencies which can result in so singular a law. The resultant time for the true rotation is 25·19 days for a point at the sun's equator, but 27·25 days for a spot at 40° of latitude.

This interesting discovery reconciles the perplexing and apparently conflicting observations of various astronomers, by which the same spot, when visible through several successive rotations, has appeared to indicate a different period at each rotation: for it is thus manifest how the phenomenon can result from a slight increase of distance from the sun's equator, such as would be produced by the moderate currents which probably set toward the poles at a rate not exceeding twenty-five miles an hour. These currents cannot be uniform, or very regular; indeed, they may to some extent be produced by means of the spots themselves, and our knowledge regarding them is very limited. It has ever been maintained‡ that their general tendency is toward and not from the equator, a view to which observation seems to lend but little support,|| but the possibility of which illustrates the comparatively small amount of motion which really exists, as well as the indefiniteness of our knowledge. A tendency in neighboring spots to approach each other, as bubbles do upon a liquid surface, has sometimes been observed, but more frequently a mutual repulsion; as also a repulsive action of a spot while in the act of breaking out, and the motions thus arising interfere, of course, with our measures of the velocity of rotation.

(To be continued.)

* *Observations of Solar Spots*, &c., p. 224.

† *Comptes Rendus*, LIX, 481; LX, 142; LXVIII, 197.

‡ *Proc. Amer. Assoc. Adv. Science*, 1855, p. 88.

|| *Carrington, Observations, etc.*, pp 220, 222.

EVOLUTION, AS AFFECTING THE EARTH'S CRUST.

[A Lecture delivered at the Franklin Institute, December 8th, 1870.]

By Prof. Leeds.

(Concluded from page 133.)

At last that great day came when the particles of oxygen and hydrogen had so far decreased in temperature, that is to say, commenced to move in such restricted spheres, that it was possible for them to link their divided existences into one. With that act of union, water—water, the physical life-blood of the world, came into being. Water is to our earth what blood is to the life of man, what sap is to the life of plants. Indeed, water is blood and sap, for they both consist almost entirely of water, to which are added those distinctive elements that give to blood and sap their distinctive character. It has been said, and with truth, that a man is composed of a handful of dust, spread through six pailsful of water. All vegetables and animals are composed of water, together with some charcoal and nitrogen. A great number of the eight hundred species of minerals now known to exist are *hydrates*, that is, consist of from one to forty parts water, along with other ingredients. The tiny particles of water, like fairy ships, more precious to the well being of mankind than Spanish galleons heaped with gold, are freighted with the heat poured down upon the burning sands of the Niger and Amazon, and carry it to the shores of Greenland and the polar seas. Ever at work in our atmosphere, these particles of water are taking heat from this point, where it might harm or kill, and bearing it yonder to nourish and to bless. Water is the great mediator. It is the medium by which animals and plants discharge their functions; by which all parts of our earth, however distant, act and react one upon the other, and by which the physical life of the globe, considered as an organic whole, goes on.

As it is now, so was it in those pre-historic times, before the present geologic day had yet dawned. Heretofore we have been regarding the earth only as a scene of action of those demoniac powers of fire and flame such as the poets fabled Pluto to have reigned over in the abyss of Hades. Hence termed Plutonic forces. But now this blessed mediator makes his appearance, and the life of the world forever emerges from the dreary realms of Night and Chaos, and dwells under the cheerful eye of Heaven. Then, for ages so numerous that our arithmetic fails to count them and our minds to apprehend, a fierce conflict went on between the fiery or Plutonic

and the aqueous or Neptunic agencies. At first did water fare badly in the conflict. In vain did the aqueous particles, at first diffused throughout the atmosphere in the form of vapor, marshal themselves into orderly array, and rain down upon the enemy. Met by the molten surface of the earth, they were repulsed a myriad of times and driven back in rout and confusion. But their fiery enemy was ever growing weaker, until at last he was no longer able to withstand their repeated onslaughts, and the water settled down upon the cooled and hardened crust of the earth, forming an envelope of nearly uniform depth about it.

But, as yet, the shell or pellicle (at first no thicker in proportion to the bulk of the earth than its filmy envelope to the soap bubble) was plastic and yielding in a very high degree. It obeyed the same laws which affected the water above it and the fluid rock beneath. It rose and fell as every onward revolution of the earth brought successive portions beneath the moon. It felt the drawing of the Sun, and Jupiter, and other planets, and was thrown, as the sea is thrown, into conflicting perturbations by their varying influences. It rose and fell upon the tide like some mass of tangled sea-weed upon the face of ocean. And if anywhere it hardened beyond the possibility of yielding, it either cracked, and the basalt flowed from beneath to repair the breach thus made, or it stood firm until some tide higher than all preceding raised the crust into a fold or mountain range.

There were two distinct classes of phenomena which attended the cooling of the globe. In the first place, a cooling of the entire mass, which would diminish the earth's diameter, causing it to shrink away from the hardened crust and leave an open space between core and shell. Secondly, a contraction of the crust itself, which would cause it to break into pieces and fall down into the molten mass below, floating there like so many islands in the sea. If these two contractions went on at the same rate, the surface of the globe would have assumed the form impressed upon it by the balance of its gravitating and centrifugal forces; it would have become a regular ellipsoid, its crust shrinking regularly down with its fluid centre, like a distended India rubber balloon upon a contracting ball within. But nature presents us with a very different state of affairs. There is one gigantic series of mountains upon the earth's surface, and we put them altogether under one name, and call them dry land, and an equally great series of valleys, where is ocean. As remains of temples upon the shores of the Mediter-

ranean, now standing high above the blue waters, show by their worm-eaten sides that at one time they were sunk beneath the surface of the sea and afterwards rose to their present position, so great beds of rock now forming our hills and mountains, which are pierced by marine animals and filled with their shells, must once have been below sea-level. It is by such evidence that we are driven to the conclusion that the lands and seas have undergone vicissitudes almost numberless during the lapse of geological history. A large part, if not all the present terra firma has been beneath the sea, and the sea has been dry land. What are now table lands have been meadows, and where are now the highest mountains have once been valleys. These are mighty changes, and we must look to something equally potent and vast if we would arrive at adequate causes.

Such causes I find to lie in the unequal degree of rapidity with which the fluid nucleus and the hardened crust of the earth contracted. Unequal for two reasons: 1st. Because the rate of cooling of the surface, separated from the intensely cold abysses of space only by a canopy of convecting gases and vapors, was very rapid—much more rapid than the nucleus with its envelope of badly conducting rock. 2d. Because the rate of shrinkage attending the cooling of a rock in the solid, as compared with the liquid condition, is much slower. You all are aware that we employ some liquid, such as alcohol, water or mercury, and not a solid metal, in the construction of thermometers, for the reason that, although the latter would contract on cooling and expand on heating, yet not sufficiently so to indicate slight changes of temperature. Let me recapitulate. In virtue of the more rapid radiation from the surface, the crust would crowd down upon and squeeze the molten mass within. In virtue of the more rapid decrease of volume in a liquid, as compared with the same body in a solid condition, the nucleus would contract away, and leave the crust standing in an arch above it. This arch, unable to bear its own weight, would fold in upon the retreating centre, and thus the surface of the earth would be puckered up into mountain chains and valleys. If, in the process of folding, the surface cracked, its fissures were filled by trap and syenite, basalt, serpentine and granite, which served like mortar to bind the foundation stones of the preadamic world together. If, on the contrary, the crust cooled more rapidly than the nucleus, and pinched the lavas within, it caused them to be projected through the rents with volcanic force.

It is worse than useless to attempt to arrive at valuable conclusions concerning this matter by a simple process of reasoning. Either of the operations alluded to is competent to produce all earth's mountain chains and dykes. The facts necessary to settle the question are within the reach of experiment. After an accurate experimental determination of the amount of contraction of the igneous rocks when in a solid and a fluid condition, it would be possible, by a laborious, though not particularly difficult calculation, to decide the question with mathematical certainty.

Having watched the various stages through which the earth's surface passed, until we have arrived at a time when its continents were raised from the deep and diversified with valleys and hills, let us now turn our attention once more to its atmosphere, and consider the alterations which it underwent during the same interval. We have already, as I pointed out in an earlier portion of the lecture, arrived at a period when the earth had lowered in temperature to such a point that the water forming the ocean and seas could rest upon it. As the process of cooling went on, the vapors were precipitated. The air became clearer, and the fiercely rolling masses of cloud became less vast and dense. Still, no light shone upon the earth as yet, except what came from some yawning crack or awful gulf in the thin crust, where torrents of ancient lava came out from below and spread themselves upon the heaving surface. That you may have some idea of the multitude of such eruptions, I would say that the earth is as full of these vent-holes as a sponge is of pores, or a piece of coral of tubes. The lurid flames illuminated the skies, and, reflected from cloud to cloud, from cloud to earth, were carried from the zenith to the pole, and lit up our planet like a flaming star. But as the vapors grew thinner, the rays of the sun penetrated deeper and deeper, and finally shot down upon the surface.

At first, nought but that portion of the solar beam which is invisible—its heating or calorific rays—attained thus far. Then the darker rays of red made their appearance, and the sun looked down with blood-shot eye upon the surface.

It is doubtful whether, up to this time, and indeed until the light-giving and chemical rays of the sun pierced the terrestrial atmosphere, and the solar beam in all its entirety and completeness penetrated to the earth, any animals and plants existed.

We come now to a question of the gravest importance—one, indeed, that outranks almost every other in its magnitude. We

have been studying the development of the earth's surface, and have seen that up to this point in its history, this development has been of the kind termed Evolution, that is to say, it has been a development of a later from an earlier stage, by the action of purely natural and physical laws, without any break or discontinuity, and without involving the necessity of an extraneous force, or the interposition of a higher power. Now, the evolution which our world's history presents us with is from a lower to a higher stage of development—from the simple to the complex—from what is rudimentary to what is perfected. It has been ever onward in its movement and in its tendency upward. I venture to propose for it the term Progressive Evolution.

Now, the fact that all evolution which the world's history exhibits has been progressive in its tendency, has been a serious difficulty to many. Why, they ask, if one state is derived from another by the unassisted action of physical laws, should we not find that the result of development is sometimes to elevate, but as frequently to degrade? As in the history of nations the operations of purely moral causes has sometimes brought with it wealth, power and culture, at other times has caused great monarchies to lapse into barbarism?

I answer that such is the case in nature. That Evolution is presented to us in two phases, or aspects, one of which is progressive and the other is retrogressive. The sun, the earth, and most probably Venus, Mars and Jupiter are in the progressive phase of evolution, while other planets are in the retrogressive. One of them, the Moon, after passing through all stages of progressive and retrogressive evolution, exhibits the dead, inert, exhausted condition to which a planet is reduced at the close of the downward movement. The accessions of force, including under that term heat, light, electricity and magnetism, derived by the earth from the magazine within and from the sun without, are of such an amount at the present time as to bring the earth into a state peculiarly favorable to the creation and maintenance of all the higher forms of animals and plants. At the beginning, during those stages of evolution to which I called your attention in the earlier portions of the lecture, the process of evolution, though progressive, had not yet advanced to the point at which animal and vegetable life, even of the most rudimentary kind, was possible. Then it passed through long centuries of growth, through the lisping speech and the feeble steps of infancy, when all the forms of life were of the kind that naturalists term embryonic, until manhood was attained. And now we are living far along in its prime. But the same stern reasoning, based upon the unalterable operation of the physical forces, teach us the melancholy truth that a time must come when the supply of heat upon the earth's surface will fall below its expenditure. Then it must pass, as the moon has passed, through all stages of retrogressive evolution, down to death and sheer oblivion.

I said above, that the ordinary operation of physical forces is amply sufficient to account for all the changes which took place upon the earth's surface, up to the time of the appearance of the first germ of something organized, of something which could move of itself, and did not derive the ability of motion from some force without. And if the chemist in his laboratory can produce everything which is not made up of organs, and composed of carbon, nitrogen and the elements of water, in other words, all organic bodies, Nature, which is the greatest of all chemists, could have done the same. Whether nature could have produced the material of which animals and plants are composed—that structure which makes up the walls of a cell, which chemists, looking from a chemical point of view, call Protein, and naturalists, regarding it from a histological stand-point, term Protoplasm—I dare not, without more thought and study than I have yet given to the subject, pronounce an opinion.

There is a matter, however, of still greater importance than the preceding. It deserves to be reckoned of infinite and eternal importance. It is the following:—granting that physical forces could have originated cell-structure, could they ever have determined the formation of a cell, or the aggregation of two or more cells so as to form a living organism?

As yet, all the experiments that have been tried, and all the reasoning which has been brought forward, have failed to show that such an effect could have resulted from material forces alone.

LABORATORY APPLIANCES.

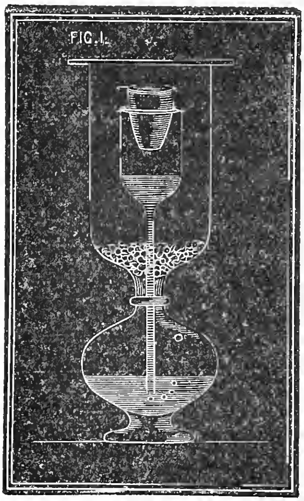
By Prof. Leeds.

New Form of Dessicator.—The dessicator in most common use, as is well known, consists of a low broad glass bottle, the outside of which is fitted by a ground glass joint to a glass cover. The inside is partly filled with fused calcic chloride, and the platinum crucible is supported either upon a glass tripod or upon a platinum triangle. It has the objection that the air in the interior expands when the hot crucible is introduced, and lifting the lid makes it escape. On cooling, a partial vacuum is sometimes produced which renders it difficult to remove the lid. To obviate this difficulty a hole is frequently drilled in the cover. But in doing so it makes the ground glass joint of little benefit, and the apparatus thus arranged is little if any better than a bell-jar set upon a ground glass plate.

Schrötter's dessicator provides for the free egress of air in contact with the hot crucible. It consists of a bell glass placed upon

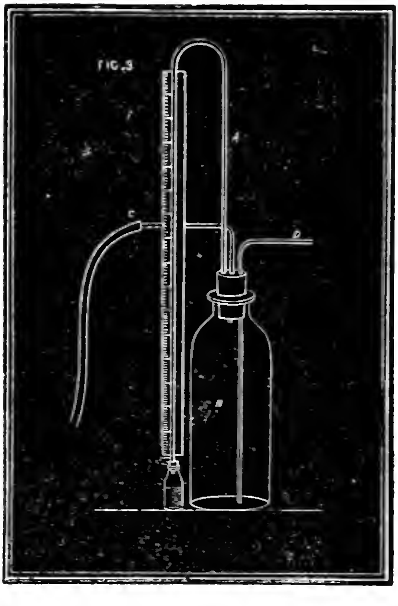
a glass plate and containing the crucible. Through a hole in a cork fitted to the tubulure of the bell-jar a fine glass tube is passed to allow an escape of the heated air. This first tube is inclosed in a second tube, somewhat wider, closed at its upper end, and with holes drilled in the lower end, through which the air passes and bubbles up through sulphuric acid contained in the bottom of a third tube that includes the other two. The top of this outer tube terminates in a bulb opening upward, which is filled with calcic chloride. When a partial vacuum is produced in the interior, the air is made to pass through the sulphuric acid before re-entering and thus dried.

A more compact and convenient dessicator is represented in the woodcut. It consists of the base of an alcohol lamp, which is ground into the tubulure of a small bell-jar. The base is partly filled with sulphuric acid, and has a hole drilled in the side near the top to permit the the egress of air. The bottom of the bell-jar is covered with fused calcic chloride and the top by a ground glass plate. One of the two disks which are used to exhibit the cohesion between polished glass surfaces answers nicely. Through the tubulure a funnel with a very large bulb is passed, its end dipping somewhat beneath the surface of sulphuric acid. The platinum crucible is supported in the mouth of the funnel by a triangle. When the air is heated by the introduction of the crucible it bubbles up through the acid and makes its escape by the opening at the side. On cooling, the air forces the acid through the tube and partly fills the funnel, but as soon as the surface of the acid sinks below the end of the tube, air bubbles up through the long column of sulphuric acid until equilibrium is restored. The calcic chloride insures complete drying. It is hardly needful to say that the tube of the funnel is supported in the tubulure by an air-tight joint.



Water Air-Pump.—When the water air-pump is used in connection with a bell-jar and beaker, such as I described in a former

number of this *Journal*, a difficulty is encountered arising from the bursting of air-bubbles contained in the water, so soon as the latter finds itself in a vacuum. In order to obviate this difficulty a number of expedients were resorted to, the one figured in the woodcut proving most satisfactory. To the end of the funnel tube, which is passed through the tubulure of the bell-jar, a very small funnel is connected by a short piece of india-rubber tubing. The ends of the funnel tubes are ground so as to bring them as near as may be in contact. They may be fused, but this not only requires careful workmanship, but was found to be an arrangement very liable to accidents from the rigidity of the parts. The tube of the little funnel is bent in such a way as to bring one of its sides nearly vertical and parallel to the inside of the breaker against which it rests. When now the bubble expands it finds itself hemmed in by the walls of the funnel, and finally breaks quietly and trickles down the vertical side of the funnel until it comes into contact with the beaker.



The exhaust of the water air-pump with which I am working at present is somewhat more than thirty-six feet in length. It is not unusual to have the barometric columns in the gauge rising to the height

of 78 c.m., and to filter under a pressure of 65 c.m. When the vacuum is allowed to stand, the water supply being shut off, the water remaining in the exhaust tube is frequently lifted and runs back. To prevent it from entering the bell-jar the contrivance represented in the above cut was resorted to. The exhaust pipe represented by D enters through the india-rubber cork of a wide-mouthed quart bottle, and passes down almost to its bottom. The tube connecting with the bell-jar to be exhausted C terminates on the inside of the bottle just below the cork, and so likewise does the tube forming the mercury gauge. When the water regurgitates it fills the bottle nearly to the top, but not a drop ever passes over into the bell-jar. On starting a fall of water again through the long exhaust pipe, the water in the bottle is entirely and at once removed by means of the syphon, and the exhaustion of the air follows immediately.

Lecture Experiments.

By Prof. Thomsen, of Copenhagen. Translated by Prof. Leeds from the *Ber. der deutsch. chem. Gesell.* No. 18, Vol. III.

Reciprocal Combustion of the Elements of Water.

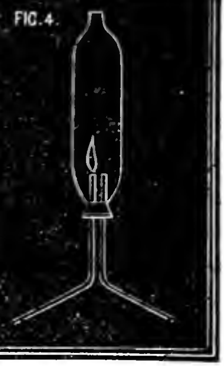
This may be demonstrated very instructively in the following manner. A pair of narrow platinum tubes, 1 centimetre long and 1 millimetre diameter are formed up of quite thin platinum foil. These tubuli are melted into a pair of small glass tubes, and are thus made the burners of the two gases, hydrogen and oxygen. The glass tubes are passed through openings about 1 to 1½ centimetres apart in an india-rubber cork. One tube is connected with the oxygen, the other with the hydrogen reservoir. After the cocks of the reservoirs are proportionately opened the hydrogen is ignited. The cork with its two burners is then inserted into a glass tube about 10 to 15 centimetres long with its upper end much narrowed down but still left open. The entire apparatus has then the form shown in the following woodcut.

The hydrogen now burns in oxygen, the fusing together of the orifice of the glass tube being prevented by the end of platinum. If now the cock of the oxygen reservoir be slowly turned off, and the quantity of oxygen so diminished, the point is soon reached at

which the supply becomes insufficient to support the combustion of the hydrogen; the hydrogen flame expands, then disappears for some moments, the flame appears at the oxygen burner, and now without any interruption the oxygen burns in hydrogen. If the oxygen cock be gently opened, the flame withdraws itself to the hydrogen burner, and again hydrogen burns in oxygen. The phenomenon can be repeated as often as desired without extinguishing the flame, provided that the increase or diminution of the stream of oxygen is not made too suddenly.

The experiment is highly captivating, and it is quite impossible for the observer who has not carefully watched it from the beginning to decide which of the two gases indeed is the combustible one. It shows the reciprocity of the combustion in the clearest manner. It is evident that while the oxygen is burning an excess of hydrogen issues from the orifice of the large tube and can be ignited there, so that the combustion of hydrogen in the air, and that of oxygen in the hydrogen, can be shown at the same time.

FIG. 4.



Combustion of Oxygen with a Sooty Flame.—Heavy hydrocarbons, like benzol and oil of turpentine, burn with a very sooty flame; with a very similar flame oxygen also burns in the vapors of these bodies. The experiment is made in the following manner. Some benzol is warmed to the boiling point in a long necked flask; the flask is closed by a cork with two holes through one of which a glass tube of about 1 centimetre bore is passed and through the other a tube somewhat narrower and bent to one side. When the vapor arrives at the orifice of the wider tube it is lighted, and then a tube through which a slow stream of oxygen is flowing is passed down into the flask through the flame. The oxygen tube is bent above, and its mouth is provided with a platinum tube fused into it. A cork upon the oxygen tube closes the wider tube of the flask: The benzol flame is extinguished and the vapor issues through the side tube, while the oxygen burns in the benzol vapor with a very sooty flame.

Easy demonstration of Oxydation and Reduction and their accompanying change of Weight.—Oxide of copper is rubbed together

with some gum water to a stiff paste, and made into a cylinder of about 1 cent. diameter and 3 cent. length. It is then dried, ignited and reduced by hydrogen at a low temperature. The reduced copper has the form of a cylinder, is very porous, but at the same time, is tenacious enough not to fall into a powder. It is surrounded with some platinum foil, the end of which is fused into a glass tube. Two tubulated bell-glasses, connected by tubes with gas-holders, are now filled, the one with hydrogen the other with oxygen. The mouth of the hydrogen bell opens below, that of the oxygen above. The gases are now allowed to stream through the bells, the copper cylinder is made somewhat warm without allowing it to attain the point of ignition and introduced into the oxygen bell. It forthwith ignites and continues to glow until its oxydation is complete. Then it cools off and the light dies away. When taken out of the oxygen and put in the hydrogen bell it begins to glow fiercely again, much water condenses upon the sides of the bell, while the cylinder is reduced to metallic copper. We have here the highly interesting phenomenon of a body, which burns twice in succession, first in oxygen and then in hydrogen, and both times with the same intense light and heat. After the second burning it is the same body as in the beginning. Since the change of weight in such a cylinder amounts to a gramme, the addition and subtraction can very easily be verified by a common balance.

A LARGE INDUCTION COIL.

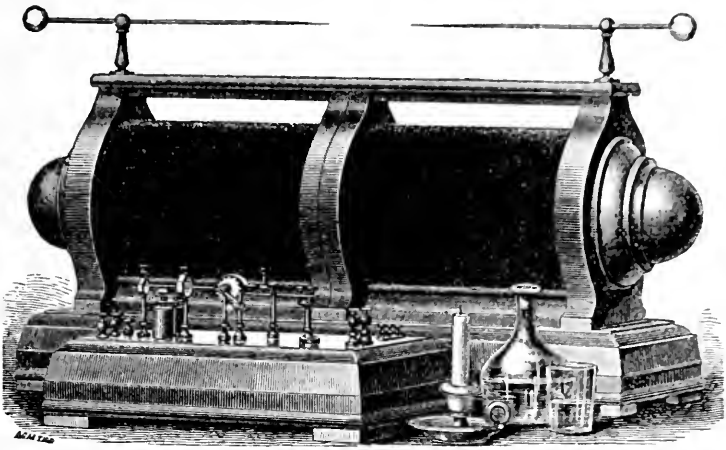
By Wm. H. Wahl, Ph.D.

An induction coil, which we believe to be the most powerful now existing, has been lately constructed by Mr. E. S. Ritchie, of Boston, for Prof. Henry Morton, President of the Stevens Institute of Technology.

Mr. Ritchie, as is well known, was the first, by several fundamental improvements, to make the induction coil an efficient and reliable source of electricity, and it would seem that by constant attention to the subject, and numerous judicious experiments, he has still kept in advance of all other constructors of these instruments, for though Mr. Ritchie's improvements were freely published and at once adopted, in some cases with anything but an ho-

norable acknowledgement, he still seems to surpass all others in the effectiveness and durability of his instruments. Thus, quite lately, a mammoth coil was built for Prof. Pepper, by Mr. App, of London, which was some nine feet in length, contained 150 miles of wire, and weighed nearly a ton. With a battery of some sixty elements, this coil yielded for a while sparks 29 inches in length, but soon failed, and is now, we understand, taken to pieces. The coil, however, now described, containing but 44½ miles of wire, 40 inches in length, and weighing about 250 pounds, gives, with but three cells of battery, sparks 21 inches in length, and after several months of constant use and severe tests, is in perfect condition.

The accompanying wood cut, which is a faithful copy from a photograph of the coil, with some familiar objects as standards of



comparison, will give a general idea of its structure and arrangement.

It is made in three parts, one consisting of the condenser, enclosed in a mahogany case, as shown in the foreground, carrying on its upper surface the automatic and hand break piece, commutator, &c., and two others, forming the coil itself. These last are so arranged that they may be separated from each other, and used either apart or united for quantity. The pole cups, by which the halves of the coil and condenser are united, have been omitted by the engraver on account of their confusing effect, as they were superposed by the perspective of the picture.

The particulars of construction are briefly as follows: The

iron core consists of iron wires, about $\frac{1}{16}$th inch thick, and weighs 14 pounds. The thickness of the wires is immaterial except as it affects their annealing. These wires are not insulated from each other, and are simply bound together with a covering of oil silk and cloth, for strength.

The primary wire is 200 feet in length and 0·1655 of an inch, or about $\frac{1}{6}$th of an inch in diameter, and weighs 17 pounds. The secondary wire is 234,100 feet, or about $44\frac{1}{3}$ miles, and ·007 of an inch in diameter, and weighs $44\frac{1}{2}$ pounds. It was made of Lake Superior copper, of the best electrical conductivity, and is covered with white silk. It is wound according to the plan devised by Mr. Ritchie, in a series of spirals representing the thickness of the wire and its insulation, and has additional insulation of paraffine paper interposed at regular intervals.

The insulation between the primary and secondary consists of glass bells and vulcanite spools, so proportioned as to offer the greatest resistance at points of highest tension, and proved by actual experiment to be 50 per cent. greater than a spark of 21 inches would penetrate, under the existing conditions. The condenser contains 325 square feet of tin foil insulated with oil silk, 100 square feet being in permanent connection with the primary circuit, and three buttons throwing on 100, 75 and 50 feet respectively, at will.

The break piece is of the combined automatic and hand movement, attached by Mr. Ritchie to all his larger instruments, the automatic break being operated by a single-cell battery, connected or thrown out at pleasure, by a button on the surface of the condenser-case.

The total height to upper surface of horizontal strip is $18\frac{1}{2}$ inches; total length of base, from end to end of round caps over primary, 40 inches; height of base, 5 inches; width of base, 13 inches; length of each section of secondary bobbin, 13 inches; external diameter of secondary bobbins, 9 inches.

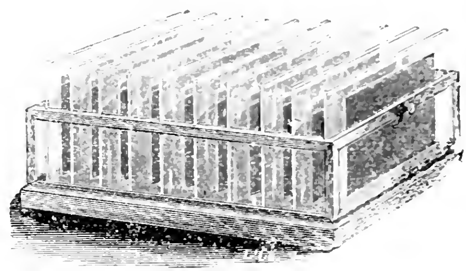
For convenience of transportation and handling, the entire coil, base and all, is divided at the centre, where a vertical crack appears in the drawing, and each half is packed in a separate box. The condenser occupies a third box, and the entire weight, when packed, amounts to 355 pounds.

The battery for exciting this coil was made according to Prof. Morton's direction, by Messrs. Chester Brothers, of New York, and

consists of three glass jars, 10 inches in diameter and 12 inches high, into which are lowered, by means of a windlass, plates of carbon and zinc, 8 × 10 inches, five of each occupying each jar. The liquid employed is the mixture of potassium, bichromate water and sulphuric acid, now used in several forms of battery. When the solution is fresh, an immersion of three inches developes the full power of the coil.

The convenience of this battery for use, Prof. Morton tells us, both at his own laboratory and when lately delivering courses of lecture in Baltimore and Washington, is beyond praise. Sparks of twenty-one inches are developed by this coil with such freedom that there would be no doubt that many inches more might be reached: but, until some important lectures during the present winter are over, he is unwilling to risk the puncture of the insulating bell jars, which would throw the instrument out of use at a critical time; although it has been constructed with a special view to the repair of such a damage, should it occur. At 21 inches Mr. Ritchie warrants the coil as absolutely safe, and constant use during several months has shown, practically, that it is so.

In connection with a leyden jar of $1\frac{1}{3}$ square feet surface, it produces sparks of $2\frac{3}{4}$ inches in length, and with one of Prof. Morton's secondary condensers (see this *Journal*, Vol. LIII, p. 256), shown in the accompanying cut, and containing 20 coated panes, it gives sparks 14 inches in length, and of the intense whiteness and loud report of the Leyden jar discharge.

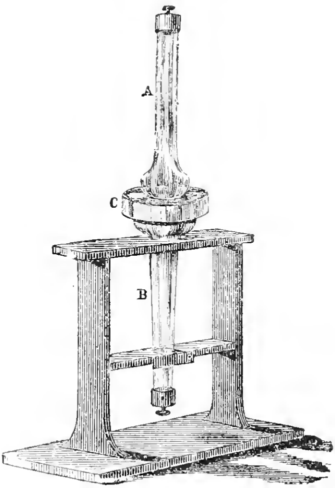


Blocks of glass three inches thick are penetrated, and seem to represent pretty accurately the same resistance as the 21 inches of air, for when the points are separated 21 inches, and other wires connected with the columns for piercing the glass, several sparks will pass in air before one with a red flash goes through the glass, then several sparks in air will occur before another spark will traverse the glass block again.

Curiously enough, the spark in glass, as in air, seems to render its path a worse conductor than before, for it rarely happens that two sparks in a thick block go, even partially, by the same route,

though the conducting points remain in exactly the same position.

The apparatus employed to pierce glass blocks is constructed as follows: Two glass hollow columns, A and B, are procured, and provided with five wires along their axes, otherwise filled in with a mixture of wax and rosin. These pillars are made very broad at one end, which is ground flat, and are provided with brass caps and binding screws at the other. They are cemented with wax and rosin, by the broad ends to the block of glass, C, to be pierced, the frame shown in the cut greatly facilitating that process.



Employed to illuminate a Gassiot's cascade when a secondary condenser of 8 coated panes is in circuit, and an interruption or spark in air likewise interposed, the amount of luminosity is truly surprising, and greatly exceeds anything that we have seen with any other coil, even those made by Mr. Ritchie to give 15-inch sparks.

When coupled for quantity the spark length is reduced to 12 inches, and the quantity is conspicuously increased, as indicated by the sound and the auriola. When the poles are about 4 inches apart, this auriola may be blown into a flame like surface, extending 3 inches from the line of discharge.

Connected with a battery of four half-gallon leyden jars, the sparks are deafening, and afford light enough to illuminate a zoetrope disk, 4 feet in diameter, so as to make the movement of its figures perfectly distinct at a distance of 60 feet.

At a future time we will give some further account of experiments with this huge instrument.

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EDITORIAL.

ITEMS AND NOVELTIES.

Heating and Ventilating Railway Cars.—We take pleasure in placing before our readers a system of heating and ventilating railway cars, which seems to meet the conditions of the problem upon more rational principles than various modes now practised. The plan referred to is that of Dr. J. G. Allen, of this city, and formed the subject of a favorable report, adopted at the last meeting of the Institute Committee on Science and the Arts. The heating is accomplished by a stove, of peculiar construction, placed beneath the platform at one or both ends of the car, which can be looked after by an attendant from the top. The products of combustion are carried off by an escape pipe, terminating above the roof of the car; and the heated air furnished by a cylindrical air-space about the fire box is led by tubes beneath the car, and supplied by openings at various points along its sides, slightly elevated above the

flooring. The ventilation is effected entirely from the bottom. Openings are pierced in several places in the centre of the aisle, through which the air escapes and is led off to a pipe terminating above the car in a cowl furnished with a flap-valve, which, while the car is in motion, protects the passage from the descent of the air current. The suction established at the free end of the cowl by its rapid passage through the air, is relied upon to produce an effective circulation of the air within the car.

The history of the process would then be about as follows: The heated air, upon its entry along the sides, rises at once (in virtue of its inferior specific gravity) to the top of the car, and is gradually forced downwards—escaping finally, with the exhalations of the passengers, through the ventilators in the flooring. The plan of ventilating apartments from the bottom has been so thoroughly established as the most economical as well as healthful, that if the mechanical details of the plan here described are as correct as the principle whose requirements they claim to meet, it cannot fail to meet with warm approval.

Road Steamers.—It is stated that during the recent severe weather, one of Thompson's road steamers carried on its regular traffic, under conditions which appear to be of great interest for Canada or Russia, where sledging is used as a necessary means of transportation. India rubber shoes do not slip on ice, and it has been found that by simply removing the steel guards from the India rubber tyres of the wheels, these engines can haul the heaviest loads over ice and snow without slipping. One of the engines was worked through a distance of three miles, daily, during the whole of the frost. Part of the distance has a rising gradient of 1 in 10, and the road steamer hauled a load of 7 tons up this incline when it was completely covered with solid ice. It is highly probable, therefore, that the steamers might be used in hauling trains of sledges with great success, and it is very possible that all kinds of traffic could be carried on with far greater ease and speed over the snow than over the ordinary roads.

A Veteran Steam Engine.—Our cotemporary *Engineering* gives the following account of a veteran engine, which possesses great interest in its bearing on the excellence of engine building during the early part of the century. At the establishment of Messrs. Frost & Son, there is now running a beam engine, built by the firm of Boulton & Watt, in 1811. The engine has a 36-inch

cylinder, with 6 feet stroke, and is run at the speed of from 15 to 20 revolutions per minute, the boilers in connection with it being worked at a pressure of 10 pounds per square inch. With the exception of about two years, this engine has been in constant use ever since its erection, and a considerable portion of the time it has been running day and night. Until within the last nine years the piston had gasket packing, and when metallic packing was then fitted to it, the cylinder was found to be perfectly true; notwithstanding the fact that it had been in use more than fifty years without having been bored out. The engine has short D slide-valves, driven by an eccentric, and some excellent indicator diagrams were taken from it a short time ago. The power indicated when the engine was doing its work was 53·4 horse-power.

A Band Saw Mill.—Richards, Kelly & Co., of this city, have just completed, for J. J. Van Pelt, Esq., of New York city, a band saw mill, of much larger proportions than any hitherto made, either in this country or abroad. The designs of Mr. Richards, of the firm, were submitted in January last, and the whole, including drawings and patterns, were built in about sixty days from the time of their approval. Mr. Van Pelt is one of the most experienced lumber manufacturers in our country, his yards being adjoining those of the French Band Saw Mills, at the foot of Tenth street, New York. It is to be presumed that he will develop many new features in this interesting problem of band sawing deep timber.

Some of the general dimensions are as follows:

Length of the blades	55 to 60 feet.
Width	5 to 6 inches.
Diameter of wheels	75 inches.
Lower shaft	$4\frac{1}{2}$ inches diameter.
Top shaft (steel)	4 inches diameter.
Range of guides	6 feet.
Total heights from foundation	about 24 feet.

The bearings are three diameters in length composed of, copper, 6, tin 1; being very hard, to withstand the strain of the saw, which will be from $1\frac{1}{2}$ to 4 tons.

We expect to visit this mill after it is in operation, and to furnish a further notice in due time.

An Alloy for joining Brass with Steel or Iron.—The difficulty of finding a material suitable for permanently joining brass with steel or iron, on account of the unequal expansion of the me-

tals, is well known; and the information which Dr. Dingler offers us of an alloy possessing the properties requisite to insure a permanent adhesion, may possess some practical importance if its claims will stand the test of practice. The composition of the alloy is:—Tin, 3 parts; copper, 39½; and zinc, 7½.

Ernst Alban's Condenser.*—The following is a description and illustration of Ernst Alban's Condenser for high-pressure engines, taken *verbatim* from his translator. The extract is offered in the hope that it may prove of interest now, when studied in connection with modern ejector condensers, and with several patents lately issued for apparatus having like parts and use.—J. H. C.

Condenser for High-pressure Engines.—"A condenser is only advantageous for a high pressure engine under certain circumstances, and then it must be of the simplest construction, with no air-pump. This pump is fortunately not necessary when high pressure steam is used, as the steam blowing out from the cylinder may be made to act in its stead. The gain of the vacuum, where it can be simply obtained, is certainly worthy of consideration.

"The circumstances under which a condenser may be favorably adapted to a high-pressure engine are:

First. "When there is an abundance of cold water at hand, without requiring much trouble or cost to obtain it.

Second. "When the engine is very large, and the gain by condensation consequently more important.

Third. "When the steam blowing out from the engine cannot be used for any useful object. This does not often happen, for there are few engines where there are not at least rooms to be heated, or water to be warmed, or something of the kind, which will give a greater advantage from the waste steam than the application of a condenser.

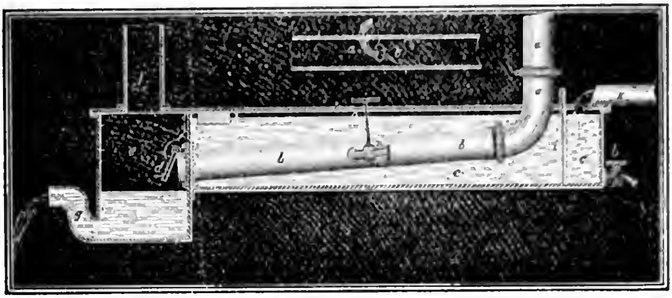
"The condenser for a high-pressure engine may be either with or without injection; in both kinds the water and air may be driven out by a blast of steam every stroke. The water should not be used for feeding the boiler, on account of the grease it contains. My condensers are in the highest degree simple, consisting only of a single pipe and a valve, with a small cock where injection is used.

Description of the Condenser.—"I have already spoken of the

* *The High-pressure Steam Engine.* By Dr. Ernst Alban. Translated by William Pole, C. E.: London, John Weale, 1848.

adaptation of a simple condenser, under certain circumstances, to the high-pressure engine.

An apparatus of this kind is shown in the annexed cut, in which *a* is the eduction pipe of the engine; *b* the condenser, a pipe of sheet-copper, the same diameter as the eduction pipe, and about twice the length of the stroke of the engine. It lies in a cistern, *c*, supplied with water from a pipe, *k*; *i* is a sieve, to prevent any particles of dirt getting into the part of the cistern from which the injection water is drawn, and *h* is an overflow, by which the waste-



water runs off; *l* is an emptying cock. The condenser is laid on an incline: the lower end projects out of the cistern into a box, *e*, and is furnished with a hanging or flap-valve, *d*, opening outwards. *m* is a small pipe, in which is fixed the injection-cock, *n*, turned by the key, *o*. The pipe is bent in the interior of the condenser, as at *a*, and has a mouth piece, *b*, so shaped as to spread the jet of water.

"The action of the condenser is as follows: At the moment the eduction passage is opened to the cylinder, the steam, having a pressure considerably above that of the atmosphere, rushes through the pipes, stops the injection, and blows the water and air collected in the condenser out at the valve *d*, into the vessel *e*. This, however, is but the work of a moment; the valve immediately falls, the jet of water again enters, and the steam is condensed. The air and vapor pass away from the vessel *e* by the pipe *f*, the water by the pipe *g*.

"I have only yet had opportunity of applying this condenser to two engines, both being single-acting, and used for pumping water. No barometer can be used with it, for obvious reasons, and therefore it is difficult to tell exactly the state of the vacuum. The best proof, however, of the efficiency of the apparatus is, that the engines.

even when they are in the most powerful and quickest action, will be stopped by simply closing the injection-cock.

"This condenser was one of my earliest inventions for the steam engine; it has been ascribed to others, but I made known a description of it about sixteen years ago; that is, about the year 1826.

Compounding Steam Engines.—The screw steamer Princess Royal has recently been lengthened 30 feet, and her original direct-acting inverted surface condensing engine has been *compounded* by placing two high-pressure cylinders on the top of the old ones, while two new cylindrical high-pressure boilers were also fitted on board. The old engines were not disturbed, and the alteration is so satisfactory that with an increased displacement of 300 tons, and the same speed, the consumption of fuel is reduced from 20 hundred weight to $11\frac{1}{4}$ hundred weight per hour. Vessels of the types generally built a few years ago can thus easily be altered to increase the carrying capacity, and at the same time reduce working expenses.—*Engineering.*

Speed of Telegraph Transmitters.—In conveying the Queen's speech by postal telegraph, the Morse printer was found capable of transmitting 40 words per minute. The Hughes type-printing instrument, which prints its messages in ordinary Roman type, sent 36 and 37 words per minute, but as no abbreviations are used, the speed is perhaps greater than in the Morse instrument where they are used. The Wheatstone automatic transmitter, where the messages are first punched out on a separate instrument, and afterwards passed through the transmitter proper, gave as the highest speed 94 words per minute.—*Engineering.*

Mechanical Engraving from Photographic Negatives.—In the interesting description of "Tilghman's process of cutting hard substances," by Mr. Coleman Sellers, in our last issue, the fact that printing from the bi-chromatized film could be accomplished in this surprising manner was mentioned. Since the article has appeared, Mr. Tilghman has devoted his time and attention to the development of this branch of his fruitful discovery, and with great success. We have been favored at his establishment with the opportunity of examining several specimens of his new art, which were sharp and beautiful reproductions from the negative.

A Monster Blast.—At the Bonaw granite quarries, Scotland, a mass of granite, computed by measurement to be about 800,000

tons, was displaced at one blast. The charge was about 8000 pounds gunpowder, and the preparation for the blast had been going on for about a year and a half.—*Engineering.*

The Bunsen Filter Pump.—In an elaborate paper of experiments, contributed by R. H. Richards, M. E., to the *Chemical News*, we glean considerable information concerning the conditions of greatest effectiveness and the relative advantages of various forms of this useful adjunct to the laboratory. The accompanying illustration shows a variety of forms which formed the subjects of the examination. In all the Figs. *a* represents the tube through which the air is drawn into the pump, and *f* that through which the water is fed.

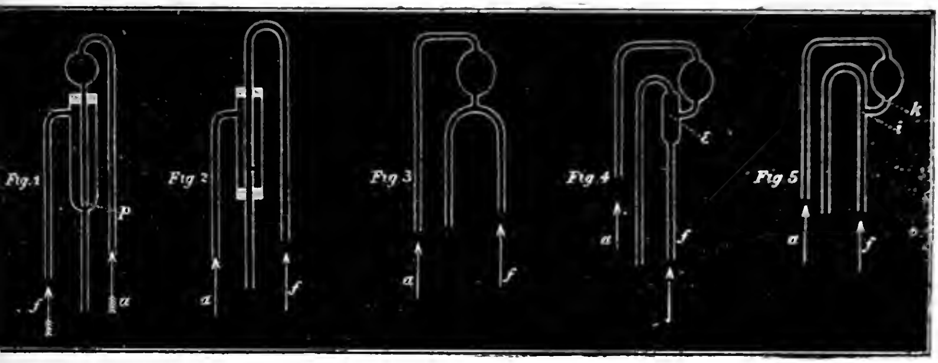


Fig. 1 is the form designed and described by Bunsen, but the author finds much difficulty in adjusting the opening of the tube *p*, so as to give satisfactory results at different rates of speed. Fig. 2, in which the water flows through a tube of uniform bore, and the air is drawn through a small aperture in its side, is described as working very fairly. Fig. 3 is a simpler form of the same apparatus. As the chief object to be attained is to secure an even flow of air and water, that the tension in the vessel to be exhausted shall not be irregular but constant, Fig. 4 was devised, in which the air is made to bubble up through a little reservoir of water, *e*. It was found that by this device the air was naturally broken up into bubbles of very uniform size, and with much regularity. Fig. 5 is a modification of this last, and possesses, with Fig. 3, the advantage of being simple in construction. With the glass blower's lamp at hand, they can be made in a few minutes by any one moderately

skillful. Fig. 3 is recommended for pumps $\frac{1}{4}$-inch or less in bore, and Fig. 5 for any larger than $\frac{1}{4}$-inch.

The data established by a number of experiments are stated by the author as follows:

1. The more water and the less air in the waste tube, the more tension.

2. Friction increases with the velocity of the flow, hence the slower the stream, the more the power.

3. The slower the rate of speed of feed water, the more power.

Lead Pipes as Water Conduits.—The influence of the metallic pipes in which water is conveyed to us, upon its healthfulness, is a matter of importance under any circumstances; but it derives especial interest just now, from the very extended attention which has recently been given to the subject by various municipal authorities. There exists a very widespread belief that water is very decidedly affected in its passage through leaden pipes—so much so, in many if not all cases, as to render the water injurious to the health. It has been abundantly proven, after faithful scientific investigation, that this view is erroneous; for there exist no authenticated accounts of the health of the numerous towns and cities supplied by leaden distributory tubes having been injuriously affected. The cause of this impunity, the English commission appointed to investigate this subject, find to reside in the extraordinary influence exerted by the small quantity of carbonic acid which the softest natural waters invariably contain. The effect of the presence of this gas is to convert the oxide of lead which may be dissolved into a carbonate, which is practically insoluble ($\frac{1}{60}$ of a grain dissolves to the gallon of water). In experiments made with the view of testing this point, it was found that pure water in contact with lead for twenty-four hours became highly poisonous, while, under the same circumstances, water containing 3 per cent. of carbonic acid remained perfectly safe.

There are, it is true, certain causes which may, to a limited extent (as in the supply of one or several dwellings), give rise to distressing accidents, such as the possible presence in the pipes of decaying organic matter, or other impurities. Such cases are, however, from their character, necessarily local, and cannot disturb the supply of a town.

The substitution of tin-lined lead pipe, block-tin or galvanised iron, have each been suggested in the place of lead, and each plan

has found warm advocates, and doubtless possesses certain advantages. It would seem, however, on examination of the subject, that while the introduction of either of these substitutes is attended with serious practicable objections, an appreciable superiority, in a sanitary point of view, is gravely to be doubted. Block tin pipe, though very harmless, is by no means as durable as lead, being rapidly decomposed by limestone waters, and is, besides, too costly for this purpose, as the supply, even with its present industrial applications, cannot keep pace with the demand.

Tin-encased lead and galvanised iron pipes are likewise open to objections, which seem to more than counterbalance the advantages claimed for them. It is, in practice, impossible to protect perfectly the surfaces of metals with others. Under the most favorable circumstances, flaws in the coating will exist, and where these occur, we have all the conditions necessary for a galvanic current—(two metals in contact with each other and an exciting liquid)—an electro-chemical action takes place, whereby the positive metal is more rapidly decomposed and taken up by the water than if present alone.

It seems, therefore, established, that taking all the essential requirements, durability, cheapness and health, into consideration, lead, for water pipes, is to be preferred to any substitute which has as yet been proposed.

It may be curious to note, in conclusion, that, in the Report of the English Scientific Commission, which, upon investigation, declared in favor of lead, the purest water analyzed during extended examination as to the most available source from which to supply the city of London, came from a lake which received all the washings from neighboring lead mines.

At the last meeting of the Franklin Institute there were shown a number of new instruments imported by Prof. Morton for the Physical Laboratory of the Stevens' Institute of Technology. Among them were—

An Improved Pocket Chronograph, by Casella.—In size and form the chronograph precisely resembles a watch, and consists of an ordinary quick train lever movement, with the addition of a centre seconds-hand, which traverses the dial, as in a stop seconds watch, but differs from it by means of the registering property it possesses. This hand is therefore double, and is formed of two hands, one lying over the other. The

lower one at its extreme end has a small cup or reservoir, with a minute orifice at the bottom; the corresponding end of the upper hand is bent so as to rest exactly over the puncture. Having supplied this cup with a thin black fluid, formed of olive oil and a little lampblack, put on with the point of a pin, wind up the instrument in the centre hole at the back, and set the hour hand by applying the key in the second hole. The small catch beside the handle must now be pushed towards the handle, to put the work in motion. If using it at a race, on the first horse starting push in the stop in the handle, which causes the upper seconds-hand to dip through the orifice in the lower one, and leave a little black spot or speck on the dial. This is repeated as each horse or boat passes the winning post, so that an indisputable record is thus obtained by these dots of the exact time of arrival of each horse or boat, as well as the whole time occupied by the race. By this method the time may be taken to the tenth of a second without the confusion and anxiety of taking the eye from the object on which it is necessarily so intently fixed. The action, if continuous, is four hours without winding up, but it may be stopped at any time by shifting the side-catch back as above.

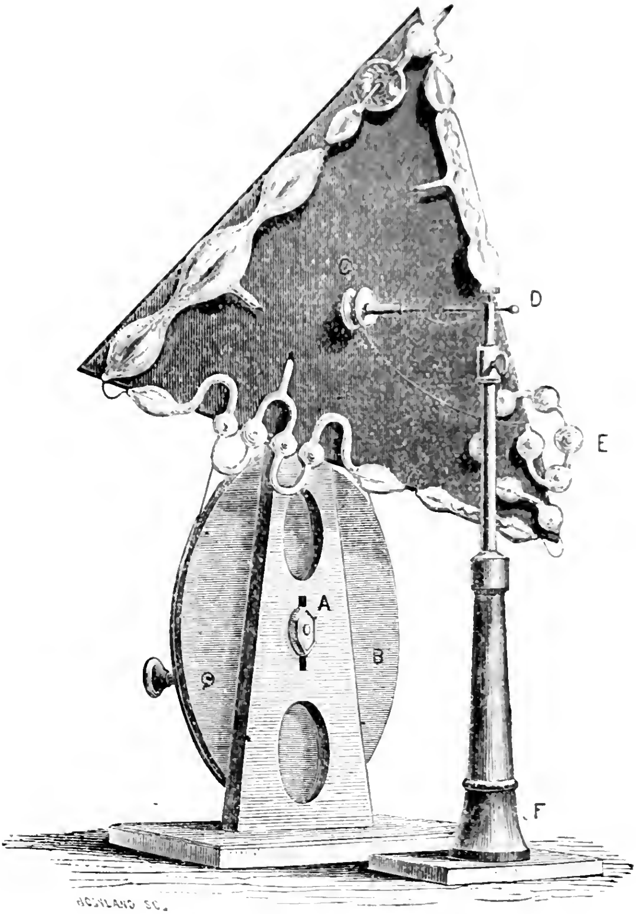
A Small Pocket Barometer (*aneroid*) by the same maker, of about the size of an ordinary watch, and capable of indicating heights up to 8000 feet, was likewise shown. This instrument indicates obviously the change in atmospheric pressure encountered in passing from one story of an ordinary house to another. Though this instrument is not capable of the same absolute precision as the standard mercurial barometer, yet for measuring ordinary changes in atmospheric pressure and for the rapid determination of heights, it is most efficient and valuable.

A Remarkable Spectrum.—An alcoholic solution of red aniline (fuchsine) containing 18·8 per cent. has a curiously varying refractive power for different rays. The index of refraction increases from Frauenhofer line B to D and slightly beyond, and then decreases very rapidly to G, from which line it again increases.

Frauenhofer line.	Index of refraction.
B	1·450
C	1·502
D	1·561
F	1·312
G	1·285
H	1·312

This gives a strange result on looking at an illumined slit through a sharp prism made of this solution; the colors are seen in the order, violet, red, yellow, the yellow being most deflected.

Gassiot's Electric Star. The well known physicist to whom we owe the beautiful experiment of the electric cascade, also devised an arrangement by which the property of persistence of vision could be rendered available in multiplying and combining the beauties of those most fascinating of electric toys, the elaborate Geissler tubes.



His plan was to attach several of them to a system of radial arms capable of rotation, while the spark from an induction coil was passing through them. The successive flashes would thus find

them in different positions in rapid succession, and this with such quickness that by pe rsistnce of vision a kaladeioscopic repetition and combination of the figure would be obtained. This plan is admirable in its effect, and is only open to the objection that the apparatus is costly, and admits of but few variations. A modification made by Prof. Morton obviates both these difficulties. A sheet of card board is taken, of any desired shape, and a number of Geissler tubes being arranged on it in such figure as may be desired, the outlines of their prominent bulbs are marked, and then with a knife or punch corresponding holes are cut. The card has then a hole punched at the point which it is intended to make the centre of rotation, and is braced by having a few light strips of wood tacked to it in convenient positions. The tubes are then tied on with strings passed through small holes in the card. The card is then fastened by a screw button, C, to the front of an ordinary vertical rotating apparatus, A B, such as is used for a Newton's solar disk. A wire from one end, E, of the series of tubes is attached to this button, and from the other end, D, to a pin supported on a small rod of vulcanite from the centre of the same button. Opposite this is the adjustable pin of an insulated stand, D F, to which one pole of the coil is attached, while the other is led to the upper pulley of the machine. The cost of such an apparatus is very small, and at any time the tubes can be arranged in a different pattern on the same card.

Sensitiveness to Light of Ferrocyanide of Potassium.— A few experiments in the direction of utilizing the instability of this salt have recently been made public by Dr. Hermann Vogel. The fact that it is a decomposable substance is a matter of unpleasant experience with every chemist; that the cause of its alteration resides in the influence of light may not, however, be generally known, though Schönbein, as early as 1846, describes the phenomenon very accurately in *Pogg. Ann.* The fact may be verified by a very simple experiment, to wit: Divide a freshly prepared solution of the salt into two parts; place one in the dark and expose the other to the action of sunlight, and even in a few hours the last will be notably darker than the first preparation. The change seems to reside in the formation of the ferrocyanide, as may be proven by adding to the altered solution a few drops of sesquechloride of iron. According to Vogel, an exposure to sunlight for even 30 seconds is sufficient to detect the formation of some ferrocyanide, and this reaction he has endeavored to utilize in the

production of photographic images. The details of the trial, as described by the author in the *Ber. d. Deutsch. Chem. Gesell*, are as follows: A paper was floated on a solution of the ferrocyanide containing 10 per cent. of the salt, and was dried in the dark. The paper gave, when exposed under a negative for a short time, only faint traces of an image, which became, however, on immersing the paper in chloride of iron solution, very distinct, and of a strong blue color, from the formation of Prussian blue. If, instead of using an iron solution, the exposed paper is immersed in a salt of uranium the corresponding compound of uranium is formed, which gives a picture of a pleasing brownish tint.

If a sensitived paper is exposed beneath a negative for a considerable time, a pale blue-black image finally appears, which is readily fixed by simple washing with water. At the close of this interesting communication the opinion is ventured that the cause of the instability of the numerous compounds at present conveniently [but very incorrectly—Ed.] called spontaneously decomposable, resides, as with the ferrocyanide, in their sensitiveness to the influence of light.

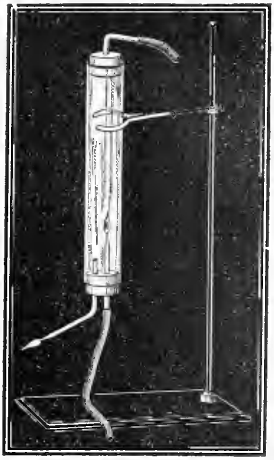
Occurrence of Saltpetre.—We lately received a number of samples of a thinly laminated sand-stone, from Tioga county, in this State, which were thickly covered, upon upper and lower surfaces, with a pulverant white coating. This proved, on examination, to be saltpetre. The statement accompanied the samples that it occurred in great quantity. In view, however, of the fact that our wet season is upon us, and that saltpetre is soluble, it appears extremely doubtful whether its stay in the county will be protracted beyond the month, even should the statement of its presence in quantity be literally true, which again is very doubtful.

A Lecture Experiment.—A number of devices, some of them simple, others complex, have from time to time been described, for showing the reciprocal combustion of the elements of water, and experiments of a similar nature.* Most, if not all of these, however, as will be found upon testing, either do not entirely remove the danger of an explosion from the operator, or they require the exercise of an unusual amount of care and dexterity to be used with success.

The accompanying arrangement, which is of the most simple cha-

* *Ber. d. Deutsch. Chem. Gesell*, III, pp. 419, 930; this *Journal*, LXI, 210.

racter, and which we saw for the first time on the lecture table of Prof. Himes, we have since repeatedly used to show the burning of oxygen, air, chlorine, &c., in hydrogen, burning gas or hydrocarbon vapors. The experiment can be performed with such ease that it is worthy of notice.



The arrangement consists of a cylinder of glass, about a foot or a foot and a half in length; (the kind used commonly as chimneys for the argand-burner can be had of proper length.) This is furnished, above and below, with a cork; the one at the upper end has one; that below has two glass tubes, of the form shown in figure. The whole affair is supported from the retort stand. The hydrogen (in the H and O experiment) is admitted through the upper tube, when it has completely displaced the air, is ignited below—(the cork having been removed)—and the supply is regulated until only a weak hydrogen flame remains. The oxygen, supplied through the straight tube in the lower cork, is now turned on slightly, and the cork fitted into its place. The flame of hydrogen at the opening is extinguished, but the oxygen, in passing up through it, is ignited, and burns now in the centre of the cylinder. The surplus of the hydrogen escapes now from the second tube below, and can be there ignited. This last flame serves the purpose of a good indicator, by which the supply of gases in the cylinder can be regulated, and which, of course, leaves the size of the flame at the will of the operator. Once in operation, the experiment may be left to take care of itself for the remainder of the hour.

Artificial Production of Coniin.—A late exchange gives us the intelligence of the artificial manufacture of the alkaloid coniin. This important discovery makes it very probable that we may yet be able to manufacture the valuable medicines quinine, morphine, and similar compounds, for the supply of which we are yet entirely dependent upon the vegetable world. The process of its manufacture is described to be as follows:—Alcoholic ammonia is allowed to act upon Butyric aldehyd at 100° C., the product of this action is combined with platinum and subsequently distilled. The pro-

duct of this distillation is an artificial compound identical in chemical and physiological properties, and [illegible] in no way distinguishable from the natural alkaloid.

A Gas Furnace of Convenient Form. Mr. Chas. Griffin has recently published an account of a very convenient form of gas furnace for fusions at white heat, the accompanying illustration of which we owe to the courtesy of the editor of the *Chemical News*. Its advantages lie in its portability, and in the fact that it does not require the aid of a blowing machine. It is stated that its heating power is sufficient to raise a $4\frac{1}{2}$-inch crucible filled with metal to a white heat. We append a brief summary of its parts and construction.

Fig. 1.

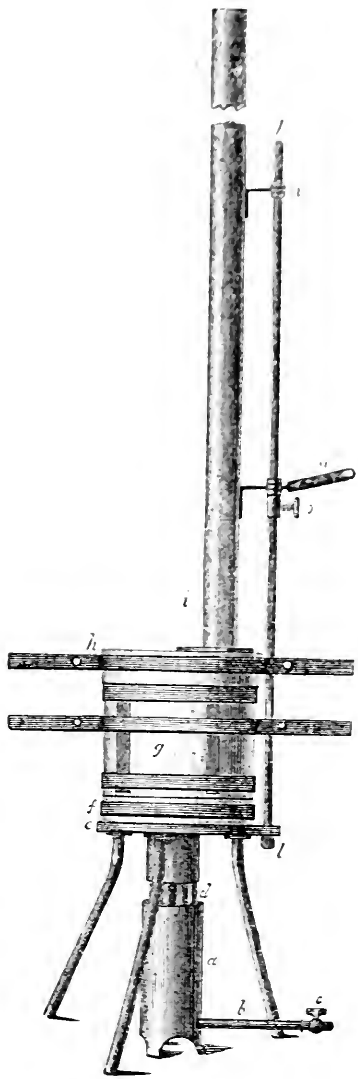


Fig. 1 represents the furnace,—height, including stool, 2 feet, external diameter, 8 inches. It consists of a brass cylinder, *a*, furnished with 16 Bunsen burners; *e* is the iron stand supporting the furnace and the iron rod, K, which holds the chimney. Fig. 2 shows the construction of *f*, the fire-clay sole plate, to the opening of which the burners are attached. *g* is a fire-clay cylinder—dimensions 6 inches height, 8 inches diameter and 5 inches bore. Figs. 3 and 4 represent a perforated black-lead cylinder to support the crucible C, which should be placed about 1 to $1\frac{1}{4}$ inches above the face of the burners. In Fig. 1 *h* represent the roof of furnace; Fig. 5 shows it in section. *i i*, (Fig. 1,) represent an iron chimney measuring 4 feet in length and 2 inches in diameter. The chimney is movable by

the handle, *m*. At *n* there is a guide and at *o* a stop, by which the chimney can be moved aside or adjusted with ease.

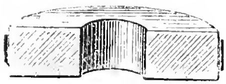


Fig. 2.

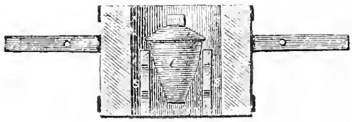


Fig. 3.

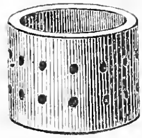


Fig. 4.

Figs. 6 and 7 represent respectively the form of grate and cylinder which have been best adapted for use with small crucibles. When the furnace cylinder, *g*, is replaced by an oval furnace body

Fig. 5.

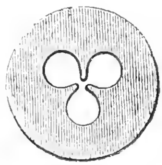


Fig. 6.

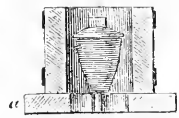


Fig. 7.

that contains a muffle as represented by *m*, Fig. 8, the usual muffle operations of cupellation, roasting of ores, &c., can be readily performed.

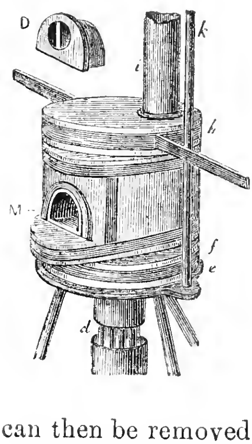


Fig. 8.

Operations that succeed at moderate temperatures, such as the fusion of zinc in an iron pot or ladle, are performed without using the dome and chimney. The vessel to be heated is to be placed on the inner cylinder of Fig. 3.

Access to the crucible in the furnace is gained at any moment by turning aside the chimney, and lifting the dome, *h*, Fig. 1. When the crucible is to be removed, the dome is first taken from the furnace, and placed on a circular plate of fire clay; the outer cylinder is next lifted off, and placed on a similar plate of fire-clay. The crucible can then be removed by the bow tongs.

Note.—A useful series of rules, formulæ, &c., for computing earthworks, by John Warner, we hope to be able to present in our next issue.—Eds.

Civil and Mechanical Engineering.

WOOD WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 89.)

Mortising Machines.

MORTISES and tenons constitute about the only means of joining wood framing where the fibres meet at an angle. In metals the joining of the material is performed by melting and by fusion when a perfect union of two parts is necessary; but in wood work, joints have to be made by what we will term mechanical connection. Mortises and tenons in wood work can be regarded as representing bolted and welded joints in metal work. As the course of the fibre in wood is an important condition, and one which must be considered in the disposition of every piece and its shape, the framing of wood structure involves an intricate as well as interesting study for the engineer.

The extensive use of wood in buildings, bridges and other structures in the United States, has developed much in the art of wood framing. Some of these works have excited the wonder and admiration of the world. The trestle work on the Catawissa Railroad Bridge, of which there is a model in the museum of the *Franklin Institute*, is one of the boldest of these works in the country—not the boldest, perhaps, in the sense of braving danger, for some of the structures erected of timber during the late war, bear off the palm in this respect. The time and means considered, there is something almost marvellous in the feats of our army in bridging the Tennessee and other Southern rivers during the rebellion. Tenons and mortises are, however, only used for keeping the parts in place in such framing as it is now constructed; the whole being clamped and held by iron bolts that receive all lineal tension. In the shops mortises and tenons for furniture, joined work, carriage work, &c., are the common means of joining material. Machines for making tenons and mortises are therefore indispensable, and

rank in importance next to those for preparing material (planing and sawing).

Mortises are made by reciprocating chisels or by rotating tools; the first making finished rectangular mortises to receive tenons formed on the common tenoning machines, the second making mortices either on straight or curved lines, the ends being circular.

The first record of reciprocating mortising machines is that of Bentham, 1796, described in his patent of that date. He also describes the rotary mortising machine, and no doubt either himself or his brother made machines of both kinds, to be used in the English prisons about the close of the eighteenth century. Hand mortising machines, consisting of a chisel bar, worked by a weighted lever, came extensively into use in England forty years later, and are yet to be found in most of their wood workshops. The treadle machine is generally used in our country in places where there is no power used, and some kinds of mortising are performed on these machines even when power machines are at hand.

There is not in the whole catalogue of wood machines, if we except jig saws, a machine that has so long baffled inventors, and that has appeared in so many modifications, as the mortising machine. Like the jig saw, it is reciprocating, requiring greatest strength just where the least amount of material must be used, and liable to continual derangement from concussion. Machines in modern use can be classed into five modifications, exclusive of rotary mortisers.

1st. The graduated stroke machine, in which the chisel bar has a graduated reciprocating motion, commencing from a still point, and progressing downward into the timber, returning to the starting point at each return stroke—differing from a variable eccentric in the matter of requiring a stroke but little longer than the depth of the mortise. Variable cranks or eccentrics that operate the chisel bar by an increased throw, in both directions, above and below the *centres*, have been applied in all conceivable forms to mortising machines without any satisfactory result.

2d. Another class of machines are those wherein the reciprocating parts, including the crank-wheel, chisel-bar and connections, are all brought down towards the timber, the chisel having a continuous motion, with a uniform range and a fixed eccentric.

3d. We have the machines with the chisel bar or its connections elongated to give the stroke, the bar and chisel having a continuous reciprocating motion, but capable of being extended to the depth of

the mortise, and yet resist in its joints the force of the blow. The writer designed and patented, in 1866, a novel modification of this machine, wherein the operator was relieved from any jar or labor in operating the chisel bar, but at an expense of much complicated mechanism, that was inconsistent with the conditions of its operation.

4th. Another modification is machines arranged to move or feed the wood to the chisel, which has a continuous reciprocating motion, the operating parts being only a crank shaft, a plain chisel-bar, and connection. These machines are the most simple that can be constructed, and have every needed function for all kinds of work when the material is not too heavy to be raised to receive the action of the chisel. They can be operated at a speed that would soon destroy machines with more detail; and have superior claims, on account of their simplicity, for general uses. They can be operated at 600 blows per minute for joiner work, and when the bed or table is properly arranged, no inconvenience from jar is felt by the operator in raising the table. At a rapid motion the jar is absorbed by the inertia of the table (which is generally made heavy), and is hardly communicated to the treadle.

One of the most important improvements in power mortising machines which has appeared since the first conception of the machine, is the automatic reversing apparatus of H. B. Smith, patented in 1854. We say reversing device, for it is known by this name, and while it performed this function as its leading object, it also held the chisel bar firmly while in motion, and prevented any possible deviation of the chisel by loose joints or uncompensated wear, which was hardly second in importance to reversing the chisel to form the ends of the mortise. An illustration of this machine is shown in accompanying plate, which shows the machines as built by Mr. Smith, of Smithville, New Jersey. They are fitted with this automatic reversing device, of which we will attempt an explanation in general terms, so far as the principle is involved. There is maintained a constant torsional strain upon the chisel bar by means of frictional or yielding connection with the driving shaft by means of a belt that "slips" upon the pullies except at the instant of the rotation of the chisel. This belt is so proportioned and arranged, that while it offers no very great amount of resistance to the crank-shaft, it keeps a continuous rotary strain upon the chisel bar, which is released by stops at each motion of the table and allowed to per-

form a half rotation. These stops on the machine of Mr. Smith are so arranged as to allow the chisel bar to make one-fourth of a revolution during a movement of one inch of the table at its lower extreme, and another fourth during its ascent through the same distance, the chisel reversing its position at each motion of the table, without any care or effort on the part of the operator. This slipping or frictional contact with the continuously moving parts of the machine can be attained in various ways. A flat belt would, however, seem to be the best adapted to the purpose. Clutches having metallic faces would tend to abrade each other, and require elastic pressure. A polished metallic surface in contact with leather has, in this case, as in other places, proved itself as the best combination for frictional contact. The round belt, however, wears well, and this part of the machine never gives any trouble.

Automatic reversing devices of other forms have been applied, generally dependent upon the feed or table movement to revolve the bar—in some cases by direct contact of spiral extensions on the bar, which come in contact with a sectional nut. To revolve the chisel bar of a mortising machine by connection with the table movement must, of course, consume some share of such movement that cannot be utilized in mortising, as the chisel must be clear of the wood when reversed. To allow the bar to come in contact with any stationary part, when in motion, would only be admissable at a slow speed; while in both cases the keeping or holding mechanism that retains the bar in position when cutting, can be nothing more than a weak spring, whose force must be overcome continually in the act of reversing. These objections are only obviated by the use of some "extraneous" force, acting upon the chisel bar independent of the reciprocating or feeding parts of the machine, which this frictional connection with the crank-shaft gives in a very perfect manner.

Among the many improvements in wood machines by English manufacturers, the mortising machine has been "left out." Their idea of mortising seems to be gathered from the metal-slotting machine. The writer has seen and examined the machines of two prominent English makers, in both of which the chisel was driven to the bottom of the mortise at the first stroke: geared in one by positive clutches, while the other had no visible means of feeding the chisel down, except by starting the machine after setting the wood. Such machines would in this country be considered totally inoperative. Messrs. A. Ransome & Co., of London, are now pre-

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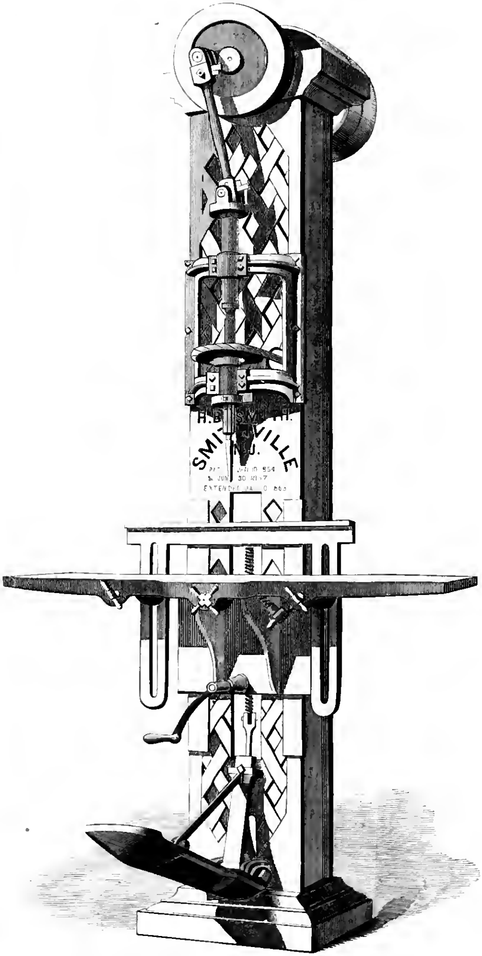

N.J.

paring patterns, and will soon produce wood mortising machines, under several modifications, to meet the varied conditions of work, of which cuts will in due time be presented.

A fifth modification is the core boring mortising machine, having a square hollow punch, bored cylindrically through its centre to receive a boring bit, the corners of the mortise being cut away by the punch or chisel; and the wood carried out by means of the screw bit working in the punch. These machines have been very successfully worked on hard wood framing, at the "Lagonda Works," at Springfield, Ohio, where they were first applied to heavy work in this country. For mortising plane stocks and window sash, and other light work, they answer a good purpose, and avoid the vibration that is common to the reciprocating machines.

Fig. 1.

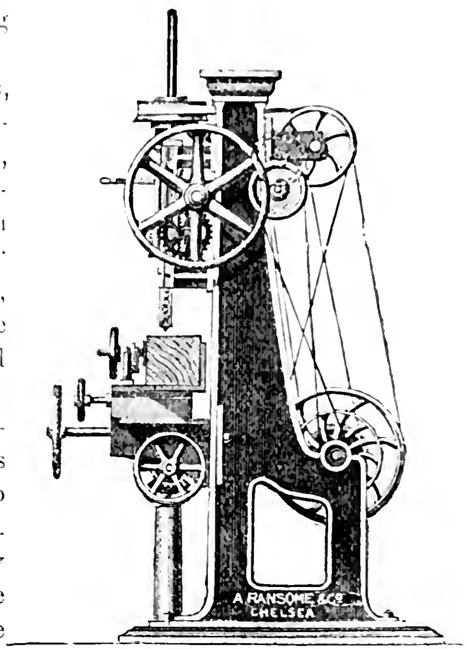


Fig. 1 is a side elevation, on a scale of $\frac{1}{24}$th, of a mortising machine of this kind, from the designs of the manufacturers, Messrs. Allen Ransome & Co., of London. It is built of two sizes, weighing respectively one and one-half and two and one-half tons.

Rotary mortising machines have as yet, in this country, been confined to light work. It is safe, however, to presume that they will, in future, come more and more into favor for the heavier class of work. M. Perin, of Paris, France, makes a good machine of this kind, which is far superior to any thing of the kind yet made in this country.

(To be continued.)

THE SUEZ CANAL.

By Prof. J. E. Nourse, U. S. N.

Not unfrequently this work is still spoken of as of doubtful completion, and of yet more doubtful success. I offer the *Journal*, in this connection, a statement of facts from recent trustworthy sources, which may throw light on the question. The want of correct information on the part of many may be well understood when one remembers the looseness of the floating paragraphs from time to time appearing in the papers of the day, the admitted want of complete success at the date of the opening of the Canal, in 1869, and the supposed want of any important bearing on American interests by a work at so great a distance from us.

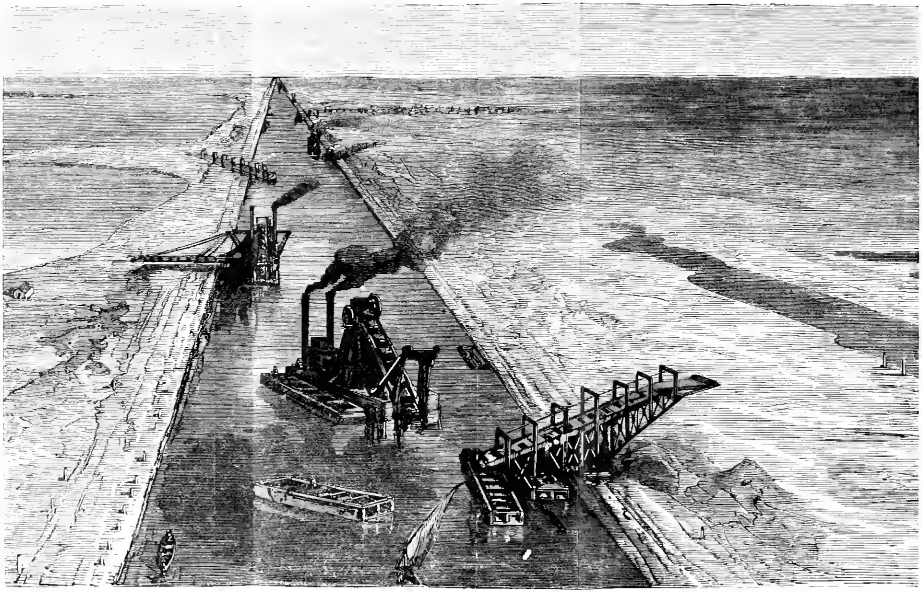
I say *supposed* want of importance to us; for it cannot be really difficult to discover that a route between Europe and the Indies, saving half the time and inconvenience for trade and travel, worked by British capital, and urging on as it does with increased activity that marvellous substitution of steam for sails and of iron vessels for wood that is going on all over the world—that such a route may have a very marked influence on American interests.

For the description of the Canal as a work of engineering, I must refer your readers to the *Engineer* and to the *Journal of the Institute of Civil Engineers*, or, more directly, to the lucid Reports of *La Compagnié Universelle*, the latest ones of which contain the plans and details of the contractors, Messrs. Borel & Lavalley.

For a short memoir of the perseverance of M. Lesseps, and of the progress and inauguration of the Canal, I may be permitted also to refer to a pamphlet* published last year, as the statements therein, are confirmed by the most recent authorities. It is worth noting that M. Lesseps' statements and promises, however flatly denied or disbelieved at the time by his English opponents, have proven themselves true, and are now acknowledged to have been such.

The Canal, according to the *London Times*, is "the event of the age;" and it is now quite pleasant for our English friends, who are getting it under the control of their money-power, to discover that Lesseps was not what they called him, the "false High Priest,"

* The Maritime Canal of Suez. J. E. Nourse, U S. N. Philps & Solomon, Washington.



but a true Apollo. The freedom of London and the medal of the Royal Geographical Society are among his latest honors.

I now condense leading facts as closely as practicable.

1. *The line of the Canal.* Port Said, on the Mediterranean, lat. 31° 3′ 37″, is joined by this route with the newly made city of Ismailia, on Lake Timsah, half way across, and with Suez, lat. 29° 58′ 37″, as its terminus on the Red Sea. The distance from the lighthouse at Port Said to Suez is 160 kilometres, about 100 statute or 88 geographical miles, of which 66 miles are actual canal, and 22 miles of the navigation are through the three Lakes, Timsah and the Bitter Lakes. Its breadth was originally planned to be of the following dimensions: the breadth to extend to 325 English feet, having a floor 72 feet wide in centre, with a depth of 26 feet, sloping up 2 to 1, till within 5 feet of the water surface, where the section is for 50 to 60 feet, either level or with horizontal benches, ending in slopes of 5 to 1. It was to have a water way, 26 feet deep for a width of 72 feet, 20 feet deep for 95 feet, and 15 feet for a width of 112 feet. By the Report of Commander Beardslee, of the U. S. steamer Palos, which passed through in August last, these dimensions (quoted from Captain Richards' previous Report to the British Admiralty) have been now secured. The *gares* or turnouts have been widened and deepened. The clayey nature of the dredgings and the coarse grass which has sprung up have made firm banks, high enough in most places to prevent more than the lighter sand from being blown over, while the amount accumulating in a year can be removed in a short time by the dredges. It is to the praise of the inventors of these powerful machines, Messrs. Borel & Lavalley, that this last statement is confirmed by a Report made to the Prussian Government in 1869, in which report it is said that one of these dredges could take out a year's accumulated sand "before breakfast." And, in passing, it may be stated that the largest are 110 feet in length, and of 75 horse-power, costing $100,000. Throughout the whole length of the Canal there is a telegraph, with a station and a Semaphore signal station at each *gare*.

2. *The Breakwaters at Port Said and Suez.*—The two jetties at Said extend into the Mediterranean 6940 and 6020 feet, enclosing an area of 450 acres, formed into a harbor of a depth in the ship channel of 25 to 28 feet. These jetties consist of blocks of concrete, of 22 tons each. Through the western pier—neither of them having been built solid—the current and westerly winds bring quantities

of silt, or deposit from the Nile, which is is gradually, though slowly forming a bank within; but this is looked upon as a benefit, in the way of an additional breakwater. It is proposed to extend this pier further into the Mediterranean, till it shall be over four miles long, as originally proposed by Hawkshaw.

A breakwater at Suez protects the Canal from southerly winds. The Egyptian government have a dry dock here, 416 feet long, with a width of entrance of 78 feet and a depth over the sill of 22 feet. One of the largest British frigates has been docked in it. The largest ships of the Peninsular and Oriental Steamship Company can lie alongside in the basin of the harbor.

3. *Approach to the ports and passage through.*—Capt. Richards, the British hydrographer, reports to the Admiralty that, under ordinary circumstances, the approach to Port Said presents no difficulty whatever; that the navigation of the Red Sea cannot be said to be dangerous, though tedious even for sailing vessels, and that the maximum speed in passing through the Canal should never, except in the Large Bitter Lake, exceed 5 miles an hour, on account of the safety of the vessel itself as well as of the banks.

The *charges* are 10 francs per ton, on registered tonnage (or exclusive of space occupied by engines and coals); 10 francs per head for passengers; and 20 francs for each 4 inches over 20 feet draught as a pilotage charge. The cost of the Canal, thus far, has probably exceeded $100,000,000; the amount of dredging has exceeded 100,-000,000 cubic yards.

I will close these notes by quoting some of Captain Richards' Conclusions, reported to the Admiralty, and by showing their confirmations by recent passages made by large vessels.

In February, 1869, Captain R. used this language: (1) "For a certain class of vessels, this great work, which must always be a monument of persevering energy and *engineering* skill as it now stands, is a convenient mode of passage from the Mediterranean to the Red Sea.

(2.) "It will be so to a greater extent when the works contemplated are carried out, viz: the deepening of the shallow parts, enlargement of the gares, and widening of the curves.

(3.) "The cost of maintenance will not exceed the estimate made when the work was first projected.

(4.) "By a different construction of our transports, this highway will be used by them with ease."

In regard to these remaining defects, Commander Beardslee reported to the United States Navy Department in August the following: "I learned that all the bad spots which existed in the Canal in February have been completed to the regulation depth and width, and my own observations confirm the most of the statements made to me about them. The steamer Delaware, 3293 tons, 380 feet in length and 36 feet beam, has safely passed." Commander Beardslee made nearly three hundred soundings on the passage of the Palos; he found, while these soundings were taken within the channel, a depth no where less than between 22 and 24 feet.

In further confirmation of the present state of the Canal, it may be enough to refer to any current number of the *London Times*, in which will be found shipping notices of the regular departures of more than thirty first-class steamers from London for Bombay, Calcutta and Japan by this route. Their tonnage varies from 1000 to 2200 tons. One of them, the "F. De Lesseps," is advertised as "under engagement with Lords of Admiralty for the conveyance of troops." The Austrian Lloyds are also advertisers of a line from Trieste to Bombay; "fare, £40, first-class." It is noticeable that the larger number of these vessels have been built expressly for the Canal route, and, as was to be expected, the number of sailing vessels advertised is almost crowded out by these steamers, although the clippers around the Cape advertise their having made the passage from Canton in 98 days, "the shortest of the season"—more than double, however, the time required by the Suez steamers. It is known, also, that an equal activity in the steam lines exists at Liverpool. The Canal is reported by the captain of the British screw steamer, the Magdala, recently arrived at New York through this route from China, as having everywhere a depth of twenty-four feet.

The passage of two of the largest vessels of the Pacific Mail Steamship Company is a fair test of the present state of the Canal. For the following returns of the measurement of these vessels, and of the passage of the Arizona, I am indebted to Mr. F. W. Bellows, of the Company's Office, in Wall street, and to Messrs. S. L. Merchant & Co., their shipping agents in New York. Messrs. Merchant are also the agents for the Coal Depots at Port Said, Ismailia, and Suez.

The Arizona has a length of 362 feet, depth of hold 30 feet, beam

46 feet. Her tonnage is 2790. She passed through the Canal successfully on the 26th and 27th of December last. Reaching Ismailia in ten hours from Port Said, she moored there at night, and was aided on her remaining part of the route by a tug, because of the high wind. The cost of her passage, including that of 126 tons of coal at 34 shillings per ton, was, in all, £955 1*s.* 8*d.*, a saving in the matter of coal and of wear of the vessel, as well as of time, very decidedly in favor of the Canal over the Cape route. The Alaska, of 4011 tons, is yet to be heard from, her departure from New York having been but recent.

The U. S. Consul at Malta, Mr. L. T. Adams, has kindly furnished a statement of the number, nationality and tonnage of vessels calling at the port of Malta on their way through the Canal during the year 1870.

From Consul Adams' registers at Malta, it appears that in 1870, 201 merchant vessels, with an aggregate of 168,068 tonnage, arrived and cleared from Malta for the Canal. To these he adds 14 men-of-war and troop ships, making an aggregate tonnage of 175,000. Their nationality is very marked. Of the 201 merchant-men, 197 were English. The facts are as striking in the statement, also furnished by the Consul, of the whole number of vessels which passed through the Canal in 1870. The entire tonnage was 444,211; the number of vessels 491, of which the British numbered 314.

It may be remarked that the tonnage of 444,000 would yield a revenue of but $888,000, at the tariff fixed by the original concession of the Canal, viz: 2 francs per ton. Increasing this revenue tonnage, by the tariff for port dues, pilotage, &c., to the round sum of one million of dollars, we have still a very inadequate return during the first year, so far as the original investment is to be considered. If, however, the canal revenues never repay the original patriotic stockholders, it will be nothing new in the history of all such enterprises. The question is, whether the saving in time, wear and expense offered to trade by this route—owning, too, as the Canal does, its dredges and large coal supplies—it will attract the full commerce of Europe.

The French political and commercial reverses are, at present, acting unfortunately on the route. The Government subsidy has been, of necessity, withdrawn from the French Messageries Imperiales Company. Notwithstanding all this, M. de Lesseps is quoted

from Paris as refusing to transfer the control of the Canal to British hands.

Is it likely that a shrewder judgment could be devised than that which we find in the *Times*, so long the uncompromising enemy of the Canal? In a leader of December 26, upon the Mt. Cenis Tunnel, that paper speaks thus:

"The Mediterranean promises to be again the chief highway of the world's commerce. The Mt. Cenis Tunnel and Suez Canal have a close relation. The far East is now certain to communicate with Europe by the Red Sea and the Mediterranean. Already passenger traffic passes almost wholly that way, and no one can say how much of the bulk of commerce may follow. Marseilles, with its new streets of grand and costly buildings, and harbors full of shipping, showing the revival of a decayed city by the commerce of this route, and Trieste, which has become the southern port of Central Europe, are, both of them, still behind Brindisi, in Italy, in advantageous position for communication with Port Said and Alexandria."

The Suez Canal, then, considered impartially from every point of view, as an accomplished fact, presents itself, to the engineer, the merchant and the historian, as one of the three events of the age: a grand monument of engineering skill; a conquest over nature, to open up intercourse and civilize the races of the East, long barred out by the desert;—one in the trio joining hands with the American Railroad and the Ocean Cable, to bind man to man.

CORNISH ENGINES.

By W. H. G. West, U. S. N.

(Concluded from page 180.)

On page 241, first paragraph, Mr. Birkinbine quotes, and questions the truth of a part of my paper upon the performances of engines, having reference to weight of moving parts, but he follows it, immediately, with a re-statement of the thing he is looking for. In the July number for 1868, page 34, Mr. Henderson says: "As a further proof of the advantage of a heavy moving mass, it has been found in practice that "Bull" engines are invariably inferior in duty to the beam variety, and that the latter description *vary in their duty in proportion to the amount of metal distributed in the*

moving parts. There are other statements of the same character, if Mr. Birkinbine thinks it necessary to find them.

Mr. Birkinbine's "valuable consideration," page 241, the possible high degree of expansion, because of immense weight, is singular, and perhaps entertaining, when we know that our best engine, that of the Easton Water Works, cut off at two-thirds ($\frac{2}{3}$) of the stroke, (March, 1870, page 156,) or expanded to one and a half ($1\frac{1}{2}$) volumes, while a rotative pumping engine of 32-inches diameter cylinder and 9 feet stroke, designed and built by the same engineer, was working in the Bethlehem zinc mine, and cutting off at 7 inches, or expanding to fifteen and a half ($15\frac{1}{2}$) volumes. The distances expanded through are one (1) of the Cornish engine to twenty-nine (29) of the rotative—29 to 1 against Mr. Birkinbine. This is my argument against excessive weight, in moving parts, to render a high degree of expansion possible.

In dealing with the portion of Mr. Birkinbine's paper which treats of steam jacketing, I beg permission to remind him that the *theories* of the gentlemen to whom he refers are built upon that splendid practice which so-called practical men are ever trying to approach. Ridicule of their perfections is no argument in favor of bad practice.

I have never heard of a steam jacket giving trouble, but it may be expected to do so in engines otherwise badly designed.

The vapor remaining in the condenser of an engine should not be over 90 degrees. The temperature will always be less than that which corresponds with the vacuum, as the latter is invariably impaired, to some extent, by the presence of the air which enters through joints and stuffing boxes, and with the water.

I do not agree with Mr. Birkinbine about his miracle, page 242. The man who made the experiment was not an engineer, as I understand the word, but he was one of the attendants who made the 130,000,000 with the same engine. The circumstance was related to me by the designer of the Easton engine. He had already profited by the lesson.

The second paragraph of page 240 states that few Cornish engines use steam above 45 + atmosphere.

On page 374, December, 1868, Mr. Henderson says, "Upon investigation I find that from sixty to seventy pounds of steam is not an unusual pressure used in the Cornish engine where a high degree of expansion is employed." ($\frac{1}{2}$?) In this instance Mr. Birkinbine is correct.

Immediately following the above Mr. Birkinbine asks a [illegible] strange question, "By maintaining a pressure *sufficiently* above this in the boiler to counteract the loss of heat from various causes in working steam, may not all the benefits of a jacket be secured in this way?"

All the heat in the sun could not do it in this way.

We admit steam for a moment; it is then cut off from the boiler, leaving no communication whatever; it is expanded, in an instance here given, over fourteen times; all the particles of steam expanding at the same time, and undergoing a reduction of temperature simultaneously. No one particle can superheat another without losing its own heat, or we have perpetual motion. The high-pressure steam must enter into the cylinder to produce any good effect. The expansion must be of a higher grade, and the condensation during expansion will be, therefore, greater. The condensation by radiation will be greater, because the difference of temperature will be increased. The leaks caused by unequal temperatures and the expansion of metals, etc., will be augmented. Leaks, such as that between the piston and cylinder, will be greater, and will increase much faster, by the use of high steam, and, generally, the losses will be multiplied to a great extent.

High steam, if not too high for the modifications imposed by imperfect practice, is more economical than low steam; but the above named, and other losses, increase with the pressure of saturated steam, and most of them with the temperature of superheated steam. A steam jacket reduces them to a minimum. High steam increases them to a maximum. If we fail to give them due consideration in designing, we do so much to diminish the duty or efficiency of the engine.

No point of superiority should be neglected, however small it may appear to be. Small defects neglected will finally destroy the efficiency of any engine. It takes but few small leaks to make a large one. Cornish engines invariably use a lantern brass to keep the piston rod stuffing box tight. A little steam is admitted to it, and the air is thus kept out. Such is their extreme care. Mr. Birkinbine, neglecting the leak of the piston, says that I am theoretically correct, but that practically it is unworthy consideration.

Theory says the expansion or leak in one case is ·1-inch. Mr. Birkinbine says that in practice it is not more than ·01, but he gives no authority; he simply guesses at it. Taking perfection, he adds

·9 to it for practice. Other engineers take ·9 from it, and are well satisfied.

The engines tested in the American Institute, of New York, were small, high-pressure engines, with, in all probability, a low grade of expansion, and with everything in favor of the unjacketed.

For the same powers developed, or combustible consumed, the radiating surface of the cylinders would be about one (1) of the high pressure to six (6) of the Cornish engine cylinder.

The rapidity of the alternations of pressure, and, therefore, of the temperatures, would make the mean difference of temperatures much less in the rotative than in the Cornish engine, and the condensation by radiation would consequently be less.

The difference of diameters of the ends of the cylinders must be considerable in the large and long cylinder, while it is very little in the small one. Indeed, the whole experiment referred to by Mr. Birkinbine is utterly worthless, as it stands, so far as large Cornish engines are concerned.

As Mr. Birkinbine insists upon throwing aside all experimental data obtained by our most celebrated physicists, and, with equal independence, determines to ignore the centuries' practice of the best practical mining and mechanical engineers that have ever given attention to the pumping of water, there is little profit to be obtained by discussing the steam jacket, if our object is to convince him only that it is a benefit.

I regret that Mr. Birkinbine is responsible for the West Philadelphia "twins" (the "Bulls"), and that I did not know he was referring to the Canal engine, but I am delighted to hear that they produced an average duty of over 600,000 foot-pounds for a whole month. When I saw them working there was evidently something wrong with the pumps. It appeared as if the passages from the well to the pump cylinders were too small, so much so that the water cylinders were only about half full when the equilibrium valves opened. The moving parts, with all the load, then dropped through half the stroke without meeting water, and of course were brought to with a violent shock. That is a strange way to reduce the supply of water, and I think one may be pardoned for regarding it with wonder. Other engines would run about half the speed to do half the work.

As Mr. Birkinbine went to London and saw for himself that the engines of that city averaged but a duty of 600,000 foot-pounds, we

are necessarily convinced that our Cornish engines are much better than the English; their famous Wicksteed engine doing about 27,000,000 less than the heretofore unheard of Easton engine. Mr. Henderson says, page 154, March, 1870, "The Cornish engines of this country, for a variety of reasons, are not equal to those in England."

How are these statements to be reconciled?

Unfortunately, for us, Mr. Henderson is right.

If, as Mr. Henderson says, there are engines running which give a lower duty than the Evans high-pressure engine, their owners will do well to present them to their enemies. They are not a credit to America, and are entirely new to me.

In regard to the interference of civil engineers with matters appertaining to another and entirely separate branch of engineering, I take the liberty of stating that the designers of all the best engines, of all kinds and descriptions ever produced, are, and have been, mechanical engineers. The best pumping engines ever built in England and America, the Fowey Consols and the Easton engine, were designed, built and erected by men who never did anything in the way of civil engineering, and who are content to spend their lives in mastering a single profession—mechanical engineering.

The "skilled mechanic" of the workshop has no more to do with making a machine than a strong laborer has to do with building a railroad, a bridge, or an aqueduct.

When the mechanic can, with profit, be put into the office of the mechanical engineer, the common miner may take the place of the geologist; the furnace man may occupy the chemist's laboratory; and the sexton may supersede the bishop. Many people attempt this thing, and the man who is so falsely and unfairly placed is only too glad to throw the blame of failure upon the American mechanic, when it is all caused by his ignorance of the true principles of design, and the desire of his employers to save a few hundreds, while they unconsciously lose thousands. So far is this misplacement carried, but still farther would Mr. Birkinbine take it by trying to force one man to learn two professions, while our leading engineers, civil and mechanical, are satisfied to do less than master one.

The "question" has led to a long discussion, which now narrows to the point at which we may ask who is right and who is wrong. If Mr. Henderson is right, his advice should be followed, but it must not be forgotten that his advice is, in effect, to build a Cornish en-

gine, good or bad, and it must beat every other of a different type, and equal any of its own type. If he is wrong, the proper course will present itself to our readers.

No one has questioned the correctness of any of the reasons given in my paper of October, 1868; they have but defended those given by Mr. Henderson.

Marine engineers invariably insure a certain effect; generally a certain speed for a certain amount of coal, of known quality, consumed, and a certain space occupied by machinery, boilors, etc. There is no such argument known as that *because* it is a *marine engine* the ship must go at a high speed. No Cornish engineer will say that because a Cornish engine is a Cornish engine, it will pump a great deal of water by the consumption of a comparatively small quantity of coal. Its correct design and construction do the superior duty.

Those advocating Mr. Henderson's views will be, and have been, of course, governed by those views in building engines. Individuals, companies and corporations requiring Cornish engines can procure them, at high prices, from the gentlemen so governed, but let them prepare to be astonished, for as long as they can be called Cornish engines, whether they are remarkably good or miserably bad, the reasons given by Mr. Henderson, and followed in construction, will prove them better than any other, and will also prove that all Cornish engines will do the same duty—this, in the face of the fact that one Cornish engine, built in America, does 94,000,000, while another does so little duty as to be unworthy of mention in the same breath with high pressure engines.

The owners of the Canal Cornish engine, having read Mr. Henderson's reasons, must feel rather perplexed at finding their engine proved to be a very excellent machine, after all the trouble they have had to keep it supplied with coal.

Cornish engineers have been experimenting and improving for scores of years; they have produced this 130,000,000 duty. More scientific men have been experimenting during the same time, and have come to the same conclusions. I but repeat what I have learned from them. I draw attention to the principles which they have established, and which govern the construction of machines in general, but which have been almost entirely neglected in the design of our Cornish engines. Singularity of appearance seems to have been the aim, and many a good shot has been made, but few good engines.

The causes to which I say the superiority of the Cornish engine is due are not purely theoretical, they come to us from the best practice. Keeping them before us we can make engines of correct proportion, and that is what the engineers of Cornwall learned to do by their long practice. All good engineers of our day base their calculations upon the results obtained from this and other experience, at the risk, it appears, of being called theoretical, yet they are successful.

If any of our readers feel sufficient interest in this discussion to take the papers written on the subject to some engineer who has built a real Cornish engine, doing good duty, say the builder of the Easton engine, at Bethlehem, Pa., question that gentleman, and compare his answers with the views we advocate, we shall know the truth, and shall have the satisfaction of seeing a change for the better wrought in the design and construction of the pumping engines of America.

This is not a simple or unimportant matter. It involves immense gains or losses. Where the Oliver Evans engine raises one pound a foot high, the Cornish engine raises more than six and a half pounds a foot high. The people of Philadelphia pay $6·50 for pumping water, while Cornish mining companies have paid as little as $1, if duties are reported correctly. If we doubt one, we must doubt all.

The people of West Philadelphia pay $1 for water, while the people of Easton pay but 70 cents, as shown by the duties reported by Mr. Henderson and Mr. Birkinbine.

Callao, Peru, July 25th, 1870.

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

By Col. O. W. Childs, C. E.

(Continued from page 29.)

It will be seen by reference to the profiles of those portions of the river occupied by the canal, that the increase in the length of the cuts through the bars which a greater depth than that upon which the estimates are based would involve, consequently the ratio of increase of the expense of the canal, would be very great. Any considerable increase to the depth would require under-water excavations between the lake and the Toro Rapids, a distance of about 27 miles, to be almost continuous: it would very much

lengthen the cuts on other portions of the river, and the liability of these artificial channels to receive deposits of earth to such an extent as to obstruct the navigation, would be very much greater. On the inland portions of the canal a depth of 22 feet of water, which is about equal to the greatest draught of the largest merchant sailing vessels, would, with 50 feet bottom width, give a transverse water section about 45 per cent. greater than a depth of 17 feet with the same bottom width; and the expense of the inland portions would also, by reason of the greater depth of excavation, be increased in a still higher ratio.

The advances in improvements of model are such as are deemed sufficient to justify the belief that vessels of a burthen as great as before stated, may be so constructed as to navigate the canal. The steam ship Northern Light, recently built of the greatest strength, for general sea service, is of recent improved model, and excellent finish; the dimensions of this splendid steamer are such as would permit her to pass with full freight through the locks and the canal, and her burthen, as stated by the proprietor, is about 2,200 tons. It is not known that there are any steam ships plying between the Atlantic States and the eastern coast of the Pacific, that have a draught as great as 17 feet.

Of 261 steam vessels, principally English, the largest portion with side wheels, and the remainder screw propellers, as given in Murray's treatise on marine engines and steam vessels, only 15 draw over 17 feet of water, 21 have 17 feet draught, and 235 draw less than 17 feet, each at load line.

To construct the canal of dimensions capable of admitting the passage of vessels of the largest draught now in use, of which there are comparatively so few, or by which it would be so little used, and under circumstances of so much greater cost, while, as is believed, merchant vessels of equal tonnage and less draught may be so constructed as to be well adapted to sea service and the passage of the canal, would appear to be an injudicious application of means, which, as is supposed, your company would scarcely favor, or the intersest of commerce require. The dimensions before given were therefore planned and made the basis of the estimates with due consideration of the disparity in cost and general utility, of a canal of larger dimensions, and with a view to practicability as referable to cost of construction, usefulness, and a fair remuneration for capital invested.

This canal, as projected, is of much greater dimensions than any hitherto constructed in this country. If we except that of the Chesapeake and Delaware, which has 10 feet depth, the largest known on this side of the Atlantic, and most similar to that under consideration in respect to connecting natural with artificial navigation, are those in Canada East, by which the navigation is extended past the rapids on the St. Lawrence River, and the Welland canal in the Western Province, connecting the navigation of lakes Ontario and Erie.

The canals connecting the navigable portion of the St. Lawrence with each other are 7 in number, varying in length from [illegible] to 11½ miles, with an aggregate length of 41 miles. They are 50 feet wide at bottom, and 90 feet at surface water line, excepting that at Beauharnois 11¼ miles in length, which is 80 feet at bottom, and 120 at top, and that at Cornwall 11½ miles long, has a bottom width of 100 feet, and a surface width of 150 feet. The locks are 27 in number, of which 20 are 200 feet in length between the gates, and 45 feet in width of chamber, and 7 on the Cornwall canal, have the same length and 55 feet width of chamber. All of the locks have 9 feet depth of water on the mitre sills, excepting 2 which have a depth of 16 feet.

The Welland canal is 28 miles long, 35 feet wide at bottom, and 71 feet at top, except a small portion, which is 45 feet in bottom width, and 81 feet at the surface.

The locks on the former portion, 24 in number, are 150 by 26½ feet, and on the latter portion, 3 in number; they are 200 by 45 feet in dimensions of chamber, all have nine feet of water on the sills. The whole fall from Lake Erie to tide water at Three Rivers on the St. Lawrence is 564½ feet, of which 536¾ is made by 54 lock, the remainder 27¾ by natural descent of the river. The aggregate length of the inland canal is 69 miles, and the whole distance from Lake Erie to Three Rivers is about 430 miles.

Sea-going vessels, carrying 350 tons, pass these canals. Although steamers and other sea-going vessels of much greater burthen pass on the St. Lawrence canals, yet owing to the want of a greater depth of water, they are understood to be limited to the above burthen. The extreme load of vessels adapted to the navigation of the Welland canal and the lakes is 400 tons of freight.

The Caledonian canal, forming a navigable connection for ships, between the east and west side of Great Britain, probably approaches in its dimensions and capacity, nearer to those proposed for the ship canal between the Atlantic and Pacific Oceans, than any other. This communication extends across the central portions of Scotland from Loch-Eil, connecting with sea on the westerly side to Loch-Beauly or Murrayfrith, an arm of the sea on the easterly side. It has a length of about 59 miles, of which 21½ is constructed inland, and 37½ is a navigation through the four lakes named in the order they occur, from West to East Lochy, Oich, Ness and Doughfour, originally of different elevations. The surfaces of Loch-Oich and Loch-Lochy now conform to the surface of the summit level of the canal; in construction, the former about 3¾ miles in length, was extensively dredged to obtain the requisite depth for navigation, and the surface of the latter about 9 miles in length, was raised 12 feet to lessen the depth of excavation through the summits between that lake and the western termination of the canal. Extensive dredgings were also made in carrying the canal through Lake Doughfour.

The canal is 50 feet wide at bottom, 110 feet at the surface water line, and 20 feet deep. It has 24 locks, with chambers 40 feet wide, and 172 feet in length. Its summit is 90 feet above the west, and 94 feet above the east sea, and the descent is made by 12 locks on either side.

Lake Ness has a length of about 20 miles, and together with the two lakes on the summit level are subject to changes of some 6 to 8 feet in their elevation by flood and drought. These flood waters are without difficulty retained for use or otherwise disposed of as the circumstances of navigation require.

This canal is similar then to that projected in Nicaragua, in its summit lake, from which in both directions it derives its supply of water, in the amount of its lockage, its dimensions, and in its frequent changes from inland canal to the adoption for purposes of navigation, of larger waters, and as also indicated from its history, (see *Encyclopædia Brittanica,*) the country, if we except climate, presented physical features, involving greater difficulties in its construction.

That canal was constructed previous to the introduction of steam as a motive power for sea-going vessels, and was designed for merchant vessels and vessels of war, of the dimensions of a 32-gun frigate.

The locks as designed for the Atlantic and Pacific Ship Canal, are large in their horizontal dimensions; they will admit of the passage of a large class of steamships, which, as a means of transit, from their annually increasing numbers, appear to be rapidly growing in favor.

The main advantages to be realized by the use of the Nicaragua canal is the saving of distance and time, in making a passage between the two oceans; these being primary causes of the extension of commerce, will in the present instance, produce benefits to be participated in by a large portion of the people of the globe. A knowledge, therefore, of this saving, to be effected by a passage through the ship canal, in making voyages between important commercial ports of the two continents, as well as between those on opposite sides of this, becomes interesting.

The following statement shows the distance between the several places named as measured on Mitchell's map of the world, Mercator's projection, and the difference in the distances between said places, by the way of Cape Horn and the proposed canal; also the time estimated to be required to make the voyages by steam and sail vessels, and the estimated difference between the two routes, in the time of making said voyages, admitting the steam to be uniform (except on the canal) throughout the several parts of the route, and to be for the steamer at the average rate of 280 miles, and for sail vessels 110 miles per day, and on the canal at rates the same as before stated.

Between what Places.	Name of Route.	Distance [illegible]	Difference [illegible]	Time occupied by [illegible] Steamers [illegible]	[illegible]	[illegible]	[illegible]
New York and California.	Via Cape Horn......	17,063		[illegible]½		155	
" " "	" Proposed Canal	5,690	11,373	2[illegible]	42[illegible]	53[illegible]	101[illegible]
" " and Valparaiso.	" Cape Horn......	10,643		41		96[illegible]	
" " "	" Proposed Canal	5,811	4,832	23½	17½	51[illegible]	42[illegible]
" " and Sandwich Islands.	" Cape Horn	16,784		64[illegible]		152[illegible]	
" " "	" Proposed Canal	7,173	9,611	28[illegible]	35[illegible]	66[illegible]	8[illegible]

The sailing distances, and the time occupied by sail vessels in making outward and homeward voyages, would, on account of prevailing winds and currents, be liable to differ widely from each other, and from those given in the above statement, which are intended to represent the time averaged for the outward and homeward voyages rather than the actual time of either. In the case of steamers, the difference would be much less, and the time estimated to be occupied by both steamers and sail vessels, averaged, as above stated, for the out and return voyage, is, upon the basis assumed, believed, nearly to be correct.

(To be continued.)

IRON MANUFACTURES IN GREAT BRITAIN.

THIRD PAPER.

By R. H. Thurston,
First Asst. Eng., Asst. Prof. Nat. Philos., U. S. N. A.; Member of the Institute.

Iron making is the most important branch of British manufactures. With the engineer it derives special interest, not only from this circumstance, but from the fact that, having been usually the first to adopt new methods and to originate new devices in iron making, we naturally expect to find in British practice much that is instructive, and look up to British makers as our tutors in the art.

In the year 1740, at which time smelting with coal had been

quite extensively introduced by Lord Dudley's successors, the production of cast iron from the 59 furnaces of Great Britain was reported at 17,350 tons. The rapid growth in production, during the hundred and thirty years that have since elapsed, to the present annual figure of 5,500,000 tons, is largely owing to the convenient proximity of the British ores to the coal beds which furnish the fuel with which they are smelted, and the source of the wealth and prosperity of the British Empire is readily found in the intelligence and industry with which such exceptional advantages have been improved.

One of the most extensive, and certainly the most prosperous and interesting of iron making localities in Great Britain, is the now celebrated Cleveland district in Yorkshire, along the valley of the Tees.

Twenty years ago this region was a barren moor, known in the neighboring counties as an excellent range for the sportsman, and *ten* years ago, Middlesborough, its river port, was a village of 7000 inhabitants, but the discovery of the ores of the Cleveland hills produced a wonderfully rapid change, and now about one hundred furnaces are in blast, and quite a number are in process of construction in this district. Middlesborough contains to-day 25,000 people.

The blast furnaces of the district are remarkable for their great size and their economy. Through the kindness of furnace proprietors and managers, we were enabled to examine the majority of furnaces situated near Middlesborough-on-Tees, and found much that was interesting and instructive in details of both construction and management.

The largest furnaces at this place are a pair, still unfinished, owned by Messrs. Cochrane & Co. They are 95 feet in height, 30 feet in diameter of bosh, and have a capacity of about 30,000 cubic feet. They will be fitted with the "Cowper-Siemens" hot blast stove, and, carrying a blast at a temperature of 1400° Fahr., or higher, are expected to produce about 900 tons of cast iron each, per week. These are exceptionally large for Middlesborough.

A pair of furnaces building by Messrs. Gjers, Mills & Co. are probably good representatives of the most approved Cleveland practice, in size and proportions. These furnaces are 85 feet high, and 25 feet in diameter of bosh, with hearths 8 feet in diameter and 8 feet high. They are built of Newcastle fire brick throughout. as are the adjacent buildings, its cost being comparatively low. The

stacks are hooped with iron bands and supported on iron [illegible] and buttresses; their foundation are of concrete about [illegible] feet in depth, the materials being very carefully selected and mixed and well compacted when in place.

The blast will be heated to about 1200° Fahr. by cast iron [illegible] blast stoves; the fuel for heating the blast, and for making steam in abundance, is obtained by utilizing the furnace gases, a chimney 110 feet high giving the required draught. Four tuyeres are used in each furnace.

At works near the above described furnaces, we found a pair in blast, 85 feet high, 28 feet in diameter of bosh, driven with a blast at a temperature of 1000° Fahr., and at a pressure of 4 pounds per square inch, entering the furnace through four tuyeres, 5 inches in diameter: the product was stated at about 400 tons each per week, on an expenditure of 20 to 21 hundred weight of coke per ton of iron made. These furnaces were fully cased with sheet iron.

Another pair of furnaces, 80 feet high and 21½ feet in diameter, with blast at a pressure of 3¼ pounds and temperature of 1175° Fahr., were claimed to be running on 19 hundred weight of coke per ton of iron, while still other furnaces, of greater size, were expected to yield a ton of iron upon an expenditure of 18 hundred weight of fuel.

Still another pair of furnaces are 76 feet high and 23 feet in diameter of bosh. The blast, heated in Cowper stoves, enters the furnaces at a temperature of 1400° Fahr., through 5 tuyeres in each furnace, and at a pressure of 3¼ pounds. The product is stated at 1000 tons per week from the pair, their unusually large production being undoubtedly due to the high temperature of the blast.

The furnaces of the Ferry Hill Company, at some distance from Middlesborough, are said to be the highest in the district; they are 27½ feet in diameter and 103½ feet high. They were stated to be working with the blast at 1400° Fahr., and to be making 550 tons of iron each per week with 450 tons of coke. If this statement is correct, they are probably the most economical furnaces in the world, in the item of fuel.

The size and proportions of furnace that seemed most generally approved by Cleveland engineers was about 85 feet high and of a diameter of bosh equal to, or rather less than, one-third the altitude, with a hearth having a diameter of about one-eleventh the height. The larger number of furnaces in process of construction were of

about these dimensions, but some proprietors were indicating their conviction that much greater dimensions may be adopted with profit, by investing their capital in structures like those of Messrs. Cochrane & Co.

The gases from the furnace top are invariably taken off and thoroughly burned in the hot blast stoves and under the boilers. The "cup and cone" arrangement is always used at the furnace top, but there is a variety of devices for opening and closing in charging.

The hoists are of various kinds, the hydraulic, the steam and the pneumatic hoists all having their advocates. We examined them all carefully, and were very favorably impressed with all. The Howson steam hoist and with Mr. John Gjers' elevator; both worked with great smoothness, and it was a pleasure to ride on them.

The blast enters the furnace, generally, through either four or five tuyeres, at a temperature of 1100° to 1200°, where cast iron stoves are used. These stoves have either the ∩-shaped or the "pistol handle" pipes, both of which are found to stand well, although exposed generally to the direct action of the flame. Pleyer's hot blast stove was highly spoken of, but we were not so fortunate as to be able to visit the Norton furnace, where they were working.

Messrs. Cochrane & Co., and, we believe, other firms, use the *Cowper* hot blast stoves, in which the beautifully simple and economical principle of Siemens' "regenerator" is taken advantage of. The cast iron stoves, with a surface of about 1250 square feet per 1000 cubic feet of blast per minute, give a temperature of about 1100° Fahr., which is very near the working limit of temperature with cast iron, but the "regenerator" stoves carry the blast up to 1400°, and even, at times, to 1700° Fahr., a temperature which compels the use of water-jackets for the valve casings.

The first cost and expense of maintenance of these stoves are claimed to be no greater than with the ordinary cast iron stove, and Messrs. Cochrane & Co. testify to a very great economy from their use. The serious difficulties which, at first, arose from the collection, in the regenerator, of dust from the gases, have been gradually overcome, and the general introduction of this stove may probably be anticipated.

The Cleveland furnace of average size costs, complete, not far from £15,000.

The ores of the district are mined in the adjacent hills. Table 1 exhibits their chemical character. The ore is an impure argillaceous

ore, from the green lias, which loses about 25 per cent. by calcination. It is roasted in kilns, of a capacity of 200 to 300 tons, each, per week, which are ranged immediately behind the furnaces, and are kept continually at work; they consume about 1 hundred weight of fine coal for each ton of ore calcined. The roasted ore contains about 40 per cent. iron.

The coke used in the furnaces is exceedingly hard, and contains 92 to 95 per cent. carbon, with sometimes a considerable amount of sulphur. It is coked at the mines in ovens, the operation occupying 60 or 70 hours, and yielding 60 to 65 per cent. of the weight of coal charged. A large proportion of the fuel comes from the neighboring county of Durham.

The flux used is a limestone, which is obtained from several localities, not far distant. The finest qualities of Durham stone contain about 96 per cent. of carbonate of lime, but some managers prefer to use a cheaper limestone, which contains some 10 per cent. less of the carbonate of lime, and which also contains considerable magnesia.

The cinder from Cleveland furnaces contains so little iron as to lack, usually, the dark color which even a slight quantity of iron oxide generally gives. A fair specimen contained about 33 per cent. silica, 23 to 25 per cent. alumina, 30 to 35 per cent. lime, 2 per cent., or a trifle less, of sulphur, and ½ per cent. or less of oxide of iron; the remainder was principally magnesia.

The cinder is run from the furnace into little iron cars, in which it is wheeled away, and, usually, thrown into the river Tees, or dumped on its bank. Explosions, resulting from carelessly throwing the hot cinder into the water, have, in one or two cases, resulted fatally to the laborers employed in its removal.

The charge adopted here will not, generally, vary far from the following: ore, 8 hundred weight: limestone, 2½ hundred weight: coke, 3 hundred weight. The amount of coke is less in the largest furnaces.

The blowing engines at the furnaces near Middlesborough have vertical cylinders, with steam and air pistons on the same rod, and with crankshaft below. The Ferry Hill engine is probably the largest in the world, having a steam cylinder 67 inches in diameter, air cylinder of 130 inches diameter, with a stroke of 10½ feet. A pair of furnaces of 85 feet heighth and 26 feet diameter of bosh are supplied by three blowing engines, whose air cylinders are 84 inches

diameter, with stroke of 5 feet, making 25 revolutions per minute with a steam pressure of 40 pounds per square inch, and a pressure of blast of $3\frac{1}{4}$ pounds.

The remarkably low cost of iron made in Cleveland is evidently due to the great size of the furnaces, to the high temperature of blast, and to the skill exercised in obtaining a complete utilization of the furnace gases, and in general manipulation. The magnitude of the furnace has been increased until an approximation to the limit of crushing strength of materials charged has forbidden a nearer approach to the theoretical limit of economy. The temperature of blast has been raised until it has reached a point at which the greatest heat which can be obtained from the gases is reached, or in other cases, at which the material of the stoves begins to yield.

Mr. Bell and other engineers have investigated, with some success, the influence of size and temperature of blast upon economical production.

The benefit of enlarging the furnace is very marked at first, but becomes proportionally less and less as the capacity increases, until an increase from 25,000 cubic feet up to 30,000, the saving amounts to 3 or 4 per cent. of fuel, and between 30,000 and 35,000 cubic feet it becomes only about $2\frac{1}{2}$ per cent., and so small an advantage is pretty nearly neutralized by the disadvantages and risks incident to such immense furnaces. Mr. Charles Cochrane states the maximum of economy to be obtained with a capacity of 50,000 cubic feet. With increasing temperature of blast, a similar decrease of gain is noticed, the economy in rising from 800° to 900° Fahr., being recorded as about 7 per cent, and between 1300° and 1400° Fahr., as $3\frac{1}{2}$ per cent.

The tendency in Yorkshire is, however, toward still higher temperatures, and the "regenerator" stoves are obtaining favor as the only stoves that can carry such high heat without injury.

The Cleveland district is said to save more than 600,000 tons of coal per year by successfully utilizing the furnace gases in producing their high temperature of blast.

The market prices of Cleveland pig iron have been quoted for some time past at from about 52 shillings per ton for No. 1, to 46 shillings for No. 4, and even at these prices there is evidently a good margin for profit, if we may judge by the rapid increase of production, which is expected, during the current year, to reach 2,000,000 of tons.

The pig iron produced is not of fine quality. It is not at all suitable for steel making, but is a fair foundry iron and when "settled" with imported magnetite or pure hematite, has given a wrought iron of quite good quality—soft, but slightly cold short. Puddling is somewhat expensive, in consequence of the cost of ore imported to mix with native, and but little is done in the district. The cast iron is exported and puddled elsewhere, furnishing a large proportion of the "ship plates" used in English iron ship yards, and finding a considerable market among rail makers.

An attempt has been made to work the "Siemens-Martin" steel process here, but it was found that the ore contained too much phosphorous to give a cast iron suitable for the purpose.

Cleveland practice in iron making exhibits most prominently the fact that, when engineers and furnace managers bring to their work a proper combination of scientific culture and practical skill, they may command success, even though laboring under the great disadvantages of impure ores and costly fuel. It is those two auxiliaries, rather than any natural advantages, that have placed the Cleveland district where it now stands among the iron making districts of Great Britain.*

Our space will not allow of as extended an account of other iron making localities of Great Britain, even had our limited time allowed as careful inspection as was made in the North Riding of Yorkshire.

(To be continued.)

* The details of construction and method in this model iron making district were studied with especial interest, with the intention of instituting a comparison with the facilities offered for the building up of a similarly prosperous business on the shore of Narragansett Bay.

The principal Rhode Island ores are a titaniferous magnetite, containing from 30 to 35 per cent. metallic iron and 10 per cent. titanic acid, and a hematite, which, when roasted, contains about 65 per cent. of iron. No sulphur or phosphorous are reported in the magnetite, and the hematite contains 0·2 per cent. of phosphorous and a trace of sulphur.

These ores are therefore much superior to the Cleveland ores, and the distance of transportation will be from six to ten miles for the ores and flux, and twenty-five for the fuel. Should the deposites prove as extensive as is anticipated, they can probably be more economically and profitably worked than any ore beds in the Eastern States. Iron, said to be of admirable quality, was made from these ores a century and a half ago, and the manufacture only ceased with the extinction of the forests which furnished the fuel. The subsequent discovery of a fair quality of anthracite, for smelting furnaces, has offered an opportunity for re-establishing the business.

AN EXAMINATION OF SOME EXPERIMENTAL FACTS BEARING UPON THE PROPER RATIO OF THE LENGTH AND BREADTH OF STEAMSHIPS.

By Alban C. Stimers, Naval Engineer.

The general success which has attended the adoption of the screw propellor in large ocean ships making long voyages is having the effect of not only driving paddle-wheel ships out of use but sailing vessels also. Now that our foreign commerce in American bottoms is almost extinct, owing to the unfavorable condition of our national affairs during the past few years, and our people are commencing to wake up to a consideration of the subject of re-establishing it, and again competing with the maritime nations of the world in the commerce of the ocean, it appears to me opportune to examine into some of the most important features of the steamship of the present with the hope of inducing a greater uniformity of practice than obtains abroad. It is with this view that I submit for publication the results of an examination of some experimental facts developed by the trials of British naval screw steamers in relation to the best proportion of the length to the breadth in that description of vessels, when constructed and employed for commercial purposes.

There is at present a great diversity of opinion and consequent practice regarding the most economic ratio of the length to the breadth of steamships, but the tendency is to greater and greater lengths as compared with the breadths.

One hundred years ago the celebrated De Chapman wrote in his *Architectura Navalis Mercatoria*, that in considering the proportions of large ocean ships generally, "that the breadth is between one-third and one-fourth the length." Fifty years later Knowles, author of a standard work on Naval Architecture, copied the exact words of De Chapman in remarking upon the same subject. These were, however, sailing vessels. When steam power was applied to the propulsion of ships, the proportionate length commenced to increase and has been increasing ever since, until now the ratio of seven to one is very moderate, and the limit of extreme comparative length to breadth is not reached within a ratio of between ten and eleven to one.

Whenever a British naval [illegible] or [illegible] an old one is newly fitted with steam machinery, it is the practice of the Admiralty to cause her to undergo a trial of speed at a measured mile; and all the particulars of construction and of the phenomena attending the trial which are supposed to influence the speed or the economy of its attainment are noted in a table kept at the Admiralty office. This table was commenced about twenty years ago, and, on three different occasions, during that time it has been published, giving the particulars and results of the trials of all the screw steamers which had been completed and tried up to the respective dates of publication. It was last published in 1865, and the list then contained the names of two hundred and fifty screw steamers. Many of these were tried several times, and the table gives the particulars of each trial.

In addition to stating the facts of construction, management and observation, the table gives the results of calculations which exhibit the economic relations of steam power and speed as compared both with the immersed midship section, and the tonnage displacement. These results are regarded as co-efficients of performance, and are, of course, augmented by any improvement whatever in the form or proportions of the immersed hull, or in the screw propeller.

An examination of the table as published shows that the variety of the combination of different forms and proportions of hulls and propellers is nearly as great as the number of vessels. Although this fact has the appearance of a barrier to a proper comparison of the excellence of one particular proportion of the hull with another, when the whole number of vessels is divided into classes having the proportion under examination properly assorted into each class, it is found that all the other items of varying proportions are pretty equally distributed through the various classes, and that therefore the mean of the coefficients of performance of each class will give a pretty fair indication of the economic excellence of the proportion thus examined.

It is upon this principle that I have proceeded to ascertain the influence of the varying proportions of the length and breadth of the vessels tried. The variation in the ratios extend from 3·33 to 7·87 breadths to 1 length, and I have divided them into five classes, as follows:—

Class A having ratios of less than $3\frac{1}{2}$ to 1 in which there are............ 12 vessels.
" B having ratios of more than $3\frac{1}{2}$ and less than $4\frac{1}{2}$ to 1 in which there are........ 65 "
" C having ratios of more than $4\frac{1}{2}$ and less than $5\frac{1}{2}$ to 1 in which there are........ 78 "
" D having ratios of more than $5\frac{1}{2}$ and less than $6\frac{1}{2}$ to 1 in which there are........ 68 "
" E having ratios of more than $6\frac{1}{2}$ to 1 in which there are........... 27 "

The coefficient employed for comparison is that which relates to the tonnage displacement, because, although the one relating to the midship section is technically useful to professional men in considering some of the detail questions of steam navigation, it does not apply to the economy of transporting a given amount of cargo across the sea, while the other does.

Although the speed at the time of the trial does not enter directly into the question, any variation in that regard being provided for in the formula which produces the coefficient, it is interesting to state it.

In the following tables, therefore, will be found the name of each vessel, the ratio of length to breadth, the speed at the time of trial, and the coefficient derived from the formula—

$$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.} = C;$$

where V = velocity in knots per hour.
D = displacement of the vessel in tons.
HP = indicated horse power; and
C = coefficient of performance.

The speed given is not always the maximum, but is that which was attained at the trial which achieved the maximum coefficient, and the coefficient given is always the maximum one where the vessel was tried more than once.

Class A having Ratios of Less than $3\frac{1}{2}$ *to* 1.

Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.} =$	Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.} =$
Aboukir	3·40	9·550	122·1	*Exmouth.........	3·40	9·100	159·1
*Albion	3·39	10·968	147·4	Goliath	3·35	9·160	101·6
Brunswick..	3·41	7·742	76·3	*Irresistible......	3·35	11·010	161·0
Centurian	3·33	8·500	108·0	*Lion	3·37	9·529	196·2
*Collingwood.......	3·37	10·460	150·9	Majestic......	3·35	8·783	118·3
Colossus	3·33	9·660	134·9	*Windsor Castle.	3·40	10·955	140·4
				Means of above 12 vessels..........	3·37	9·620	134·9

Class B having Ratio [illegible]

Names of Vessels	Ratios of [illegible]	Speed Knots	[illegible] H.P.	Names of Vessels	Ratios of [illegible]	Speed Knots	[illegible] H.P.
Ajax	3·62	7·117	91·[illegible]	[illegible]	[illegible]	10·[illegible]	[illegible]
*Algiers	3·6[illegible]	9·0[illegible]	18[illegible]	James Watt	[illegible]	[illegible]	[illegible]
*Agamemnon	4·16	11·24[illegible]	18[illegible]·2	London	[illegible]	[illegible]	20[illegible]
Amphion	4·10	6·7[illegible]0	8[illegible]·1	Marlborough	4·01	11·[illegible]	170·[illegible]
Anson	4·42	12·984	158·7	[illegible]	[illegible]	10·[illegible]	17[illegible]
*Arrogant	4·37	8·2[illegible]	1[illegible]6·1	Nelson	[illegible]·97	10·[illegible]	201·2
Atlas	4·42	13·022	147·6	Neptune	3·91	10·[illegible]97	17[illegible]·4
Blenheim	3·73	5·816	11[illegible]	Nile	[illegible]·79	8·20[illegible]	120·[illegible]
*Bombay	4·17	10·157	164·3	Orion	4·27	11·4[illegible]	1[illegible]·1
*Cæsar	3·70	10·274	167·6	Pembroke	3·63	7·602	[illegible]40·1
*Chesapeake	4·24	9·658	173·4	Phaeton	4·42	10·4[illegible]	[illegible]46·[illegible]
Conqueror	4·34	10·806	142·6	Princess Royal	3·73	11·[illegible]31	20[illegible]
Cornwallis	3·61	7·188	91·0	Queen	3·57	10·578	12[illegible]·1
Cressey	3·61	7·206	83·3	Renown	4·42	11·[illegible]0	1[illegible]·4
*Curacoa	4·46	8·668	197·3	Revenge	4·42	11·5[illegible]0	15[illegible]·6
*Donegal	4.33	11·912	173·6	Rodney	3·97	11·479	144·0
*Duncan	4·34	13·322	187·6	Royal Albert	3·82	10·9[illegible]0	174·5
Duke Wellington	4·01	9·891	156·5	Royal George	3·77	9·568	138·0
*Edgar	4·16	11·371	164·7	Royal Sovereign	4·01	12·253	1[illegible]6·4
Edinburgh	3·63	8·873	137·2	Royal William	3·90	10·581	155·5
Eurotus	4·07	7·579	92·0	Russell	3·65	6·680	104·9
*Emyalus	4·23	10·038	171·3	St. George	3·98	10·633	200·1
*Forte	4·16	11·485	175·0	*St. Jean D'Acre	4·30	11·199	200·9
Forth	3·77	9·384	146·3	Sans Pareil	3·83	9·300	133·2
Fox	3·96	9·218	141·8	Sea Horse	3·80	9·2[illegible]8	142·8
Fred'k William	3·57	11·777	157·2	Trafalgar	3·89	10·9[illegible]8	140·1
Gibraltar	4·34	12·480	142·5	*Tribune	4·47	9·551	202·2
Hannibal	3·74	8·600	131·6	*Victor Emanuel	4·16	12·0[illegible]9	190·9
Hastings	3·65	6·702	98·4	*Victoria	4·33	9·700	165·6
Hero	4·23	11·350	155·5	*Waterloo	3·94	11·329	175·3
Hague	3·80	8·328	153·4	*Zealous	4·30	10·246	177·9
Hood	4·27	11·752	156·0	Horatio	3·83	8·855	130·8
*Howe	4·26	11·161	180·2				

Means of above 65 vessels	4·03	10,051	155·2

Class C having Ratios of more than $4\frac{1}{2}$ and less than $5\frac{1}{2}$ to 1.

Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{HP}$	Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{HP}$
*Alert	5·01	9·607	183·5	*Megaera	5·47	9·958	183·6
Ariel	4 98	7·647	148·2	Melpomene	4·56	12·436	173·5
Aurora	4·53	11·335	158 0	Mutine	5·20	10·250	154·6
Bachante............	4·70	12·049	167·9	*New Castle	4 81	13·287	183·3
Bristol	4·81	10·079	159·2	*Ocean	4·67	12·896	191·5
Cadmus..............	4·96	11·825	173·6	Octavia.............	4·78	9·897	176·5
*Caledonia.........	4·61	10·713	189·4	Pantaloon.........	5·19	8·934	126·8
Challenger.........	4·96	10·601	159·8	*Pearl	4·96	10·988	202·2
Charybdis..........	4·96	11·752	138·8	*Pelorus	4·96	9·045	177·8
Clio	4·96	9·805	171·3	Peterel	5·28	8·927	153·7
Columbine.........	5·27	8·742	170 3	*Phœbe..........	4·67	9·959	226·8
*Constance	4·79	10·575	198·5	Phœnix.............	5·48	8·740	149·9
Cordelia..............	5·19	9·912	148 8	*Plumper.........	5·09	7·228	183·7
Cossack................	5·06	8·655	139·1	*Prince Consort.	4·67	10·330	219·2
*Cruiser.............	5·01	6·608	220·2	*Pylades...........	5·02	8·044	203·7
Dauntless	5·28	10·293	156·5	Racer	5·19	7·325	158·7
*Defence......... ..	5·17	11·618	203 5	*Racoon	4·96	9·958	199·1
Defiance	4·60	8·960	118·8	Rapid	5·27	7·286	137·0
Diadem	5 00	11·661	163·8	*Rattler	5·39	10·074	217·7
Doris................	5·00	11·981	145·6	*Research.........	5·06	8·220	185·4
Emerald	4·51	11·726	175·1	*Resistance..	5·18	10·372	245·7
Enterprise	4·99	8·037	175·3	*Reynard..	5·30	8·238	207·5
*Echo................	5·30	8·064	211·9	Rosaris	5·27	9·236	158·5
*Falcon........	5 03	8·653	189·7	Royalist	5·27	9·818	170·8
*Faron	5·03	7·238	179·8	*Royal Oak........	4·67	11·127	216·4
Gannet	5·19	8·445	160·5	*Satellite	4·96	9·366	194·7
*Glasgow	4·80	13·102	187·4	Secret	4·96	10·568	147·2
Greyhound.........	5·19	9·052	149·8	*Scylla	4·95	9·092	184·7
Harrier	5·03	8·320	165·0	*Severn............	4·81	11·695	177·5
*Hector..............	4·97	10·243	208·2	*Shannon.........	4·70	11·708	182·9
*Highflyer..........	5 28	9·416	177·8	Shearmater.......	5·23	8·957	124·5
*Hornet..............	5 02	7·750	197·0	*Sutley.............	4·93	13·067	188·9
Icarus	5·19	10·146	125·7	Swallow	4·98	7·429	147·4
*Immortalite......	4·82	10·940	231·0	Tartar..............	5·06	9·400	138·8
*Jason	5·45	11·632	176·7	Termagant........	5·19	10 660	141·4
*Leander............	4 74	10·276	185·3	Topaze......	4·70	12·160	175·5
*Liffey	4·70	9·072	212·5	*Undaunted.	4·80	10·972	193·5
*Liverpool.........	4·69	10·620	210·1	Valiant.....	4·97	11·433	144·4
Lyra...........	4·99	7·458	142·2	*Vulcan	5·31	9·511	185 8
				Means of the above 78 vessels...............	5 00	9·913	175·5

Class D having Ratios of more than $5\frac{1}{2}$ and less than $6\frac{1}{2}$ to 1.

Names of Vessels.	Ratio of L to B.	Speed knots	$\frac{V^3 \cdot D^{\frac{2}{3}}}{H.P.}$	Names of Vessels.	Ratios of L to B	Speed knots.	$\frac{V^3 \cdot D^{\frac{2}{3}}}{H.P.}$
Alacrity....	6·35	10·870	118·2	Orestes...........	5·53	12·265	174·1
Archer	5·51	7·520	166·0	*Orlando.........	5·77	13·001	187·4
*Ariadne...........	5·60	12·680	183·2	*Orpheus.	5·53	9·207	193·6
Arrow	6·32	11·000	156·9	Osprey	6·33	7·500	150·4
Assurance..........	6·35	9·233	176·5	*Pandora.	5·71	10·482	199·0
Barrosa	5·53	10·086	166·9	*Pelican	5·57	11·666	198·0
*Beagle............	6·32	9·409	183·3	*Penguin.........	5·72	11·078	205·8
*Brisk...............	5·53	9·309	210·3	Perseus............	5·56	10·118	170·2
*Cameleon.........	5·58	10·206	198·4	*Philomel........	5·72	10·850	212·1
*Chanticleer	5·58	11·258	188·8	*Plover	5·72	10·587	184·5
*Conflict............	5·61	9·772	178·0	Ranger............	5·72	9·006	172·9
Coquette............	6·35	7·768	173·0	Rattler............	5·58	7·692	170·0
*Cygnet	5·71	8·667	215·5	*Rattlesnake.....	5·53	12·238	207·9
Dart..................	5·72	8·708	159·7	*Rifleman	5·64	7·977	182·6
*Desperate..........	5·60	8·875	224·2	*Rinaldo..........	5·58	11·781	206·0
*Encounter	5·72	10·669	186·7	Ringdove........	6·35	10·824	149·7
*Espoir.............	5·72	9·017	180·2	Sharpshooter.....	5·65	9·327	175·5
*Foxhound	6·35	11·600	185·4	*Simoom..........	6·00	8·747	240·5
*Galetea............	5·58	10·538	216·0	Snake...............	6·32	10·303	146·2
*Greenock..........	5·69	9·630	191·4	Snipe	5·72	10·320	162·8
Griffon	5·72	10·119	177·2	*Sparrow.........	5·72	10·872	177·5
Jaseur..............	5·72	9·596	150·7	*Sparrowhawk...	6·35	9·070	178·1
*Landrail....... ...	5·72	6·870	185·1	Speedwell.........	5·71	6·712	176·3
Lapwing............	6·35	11·021	164·7	*Steady	5·72	11·053	205·8
*Lee	5·69	9·691	178·4	Surprise...........	6·35	11·149	153·3
Lynx.................	6·32	7·033	109·7	Teaser..............	5·96	7·682	123·1
*Malacca	5·59	9·094	218·0	Torch...............	5·72	10·032	174·1
Mersey	5·77	13·290	176·6	Vigilant...........	6·35	8·447	168·7
Minx...............	5·93	5·441	121·8	Viper......	6·32	11·860	176·4
*Miranda	5·77	10·750	247·5	Wanderer.......	6·35	10·733	143·8
Mohawk..........	6·35	9·925	173·5	*Wasp.............	5·51	8·176	214·2
Mullet...............	5·70	10·067	156·1	*Wolverine	5·52	11·256	193·2
*Niger	5·61	9·705	179·7	Wrangler	6·32	8·012	153·1
Nimble.............	5·72	9·933	159·6	Zebra	5·58	9·874	142·7
				Means of the above 68 vessels.............	5·84	9·842	178·9

Class E having Ratios of more than $6\frac{1}{2}$ to 1.

Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{H P}$	Names of Vessels.	Ratios of L to B.	Speed knots.	$\frac{V^3 \times D^{\frac{2}{3}}}{H P}$
*Achilles	6·52	11·879	261·1	Nimrod	6·63	8·818	175·3
*Adventure.........	7·77	10·316	237·8	*Orontes...........	6·72	10·880	253·9
*Assistance	7·77	10·663	237·6	*Pereverance	7·08	11·297	275·4
*Black Prince.....	6·55	12·221	235·8	Pioneer.............	6·59	11·366	127·7
Connorant..	6·53	11·155	154·0	Race Horse.......	6·53	10·937	143·4
Dwarf.....	7·87	10·537	115·1	Roebuck...........	6·63	9·447	165·2
Eclipse	6·53	9·274	145·0	Serpent.......	6·53	9·724	118·3
*Fairy.................	6·85	13·229	198·1	Star	6·53	11·100	115·8
Flying Fish.........	6·59	9·923	177·5	*Supply............	6·62	9·079	235·8
Flying Fish	7·19	10·409	191·7	Tamar...............	6·73	9·641	186·1
*Himalaya	7·38	12·900	297·4	*Transit...........	7·23	11·909	260·6
*Industry.	6·62	8·400	246·6	*Urgent...........	7·11	11·996	252·0
Intreped.............	6·63	10·250	118·9	*Warrior.........	6·55	11·040	289·6
Lily.....	6·53	10·000	155·7				
				Means of the above 27 vessels....	6·86	10·681	198·9

Recapitulation of Mean Results.

Class	Number of Vessels.	Ratios of Length to Breadth.	Speed in Knots per hour.	$\frac{V^3 \times D}{H. P.}$
A	12	3·37 to 1	9·620	134·9
B	65	4·03 to 1	10·051	155·2
C	78	5·00 to 1	9·913	175·7
D	68	5·84 to 1	9·842	178·9
E	27	6·86 to 1	10·681	198·9

From the foregoing classification, it is clearly demonstrated, in the most practical manner, that, within the limits of the proportions tried in the British Navy, the greater the ratio of length to breadth the more economically will a given displacement be driven at a given speed through the water; and if this was the whole problem it would not be necessary to pursue the subject farther. It is, however, only a part of it. The question requiring to be answered is, What is the proportion of length to breadth which will pay the highest dividends upon the capital invested?

BELTING FACTS AND FIGURES.

By J. H. Cooper

(Continued from page 187.)

Belts.

"The driving pulleys fixed upon the shaft should be well centered, so that there may be no inequality of motion which would destroy the belts,

"To transmit motion to the apparatus without noise or loss of power, tanned leather belts of first quality are preferably used. They wear one and a half times as long as those of inferior qualities, which, although their low price is an inducement to purchasers, are more expensive in the end, by the stretching and rapid deterioration they undergo.

"The greater or less thickness of belts often contributes to their stretching and the continual variations to which they are subject while extended over the circumference of pulleys or drums.

"For high powers, well tanned leather of sufficient thickness should be preferred. I have prepared the following table, which gives the thicknesses of belts calculated from the variable power of machinery, and the diameters of pulleys:

No. of Horse-power.	Thickness in millimetres. Pulley diam. at least = 0m·30.	Thickness in millimetres. Pulley diam. at least = 0m 20.
½	5½	5
1	6	5½
2	6½	6
3	7	6½
4	7½	7
5	8	7½
6	8½	8
7	9	8½
8	9½ doubled belt.	9 doubled belt.
9	10 " "	9½ " "
10	11 " "	10 " "

"It is rare that a force of over 10 horse-power is transmitted by means of belts.

"For a force of 8 or 10 horse-power, the belts should be double, which prevents their stretching; that is to say, two belts are super-

posed and sewed together at their edges. Thus, for a 9 horse-power two belts are sewed together, one of which is 1 millimetre thicker than the other: 5·5 below and 4·5 above, making 10 millimetres, the thickhess of a belt which will resist the action of this power and even a greater one. For low powers, the thickness is always from 4 to 5 millimetres.

Table for Ascertaining the Width of Belts.

Velocity per minute in Metres.	Width of Tanned Leather Belts in Millimetres. Force in Horse-Power						
	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{5}{10}$	$\frac{9}{10}$	1	2	3
20	68	132	328	......	......	......	......
30	44	88	220	394	......	......	......
40	34	66	164	296	......	......	......
50	26	53	132	237	......	......	......
60	22	44	110	197	220	440	......
70	19	38	94	170	188	377	565
80	17	33	82	148	165	329	494
90	15	29	73	132	147	293	440
100	13	26	66	119	132	264	396
120	11	22	55	99	120	220	330
140	9	19	47	85	94	188	283
160	8	17	41	74	82	165	247
180	......	15	37	66	73	147	220
200	......	13	33	55	66	132	198
240	......	11	28	47	55	110	165
280	......	9	24	41	47	94	141
300	......	8	22	39	44	88	132
360	......	......	18	33	37	73	110
400	......	......	16	28	33	66	99
500	......	......	13	24	26	53	79
600	......	......	......	......	22	44	66
700	......	......	......	......	......	38	56
800	......	......	......	......	......	......	50
900	......	......	......	......	......	......	44
1,000	......	......	......	......	......	......	40
1,200	......	......	......	......	......	......	33
1,500	......	......	......	......	......	......	26
2,000	......	......	......	......	......	......	20

"The transmission of motion from one shaft to another, by means of belts, depends entrely upon the friction produced by their tension upon the pulleys or drums around which they are made to move. If the force transmitted by them is augmented, the friction is in like manner increased; and if in that case the tension of the belts remains the same, their friction surface, or, what amounts to

the same, their breadth must be increased. *The powers to be transmitted are to each other as the product of the width of the belts multiplied by the velocity.*

"M. Morin has found that belts of tanned leather will resist a tension computed at two kilogrammes for every square millimetre of their section.

"When it is desired to determine the width of a certain belt *multiply the number of revolutions of the pulley or drum, made in one minute, by its circumference and the product will express in metres the desired velocity.* The width in millimetres will then be found opposite this number, and in the column of the foregoing table of the given power. If pulleys, however, are not in the relation of identical diameters, but are in the relations about to be mentioned, *then multiply the width given in the foregoing table by the coefficient of transformation.*

"*Coefficient of Transformation of the width of belts according to the relations of the diameters of pulleys.*

"For pulleys, the diameters of which are to each other as 1 : 2, the width indicated in the table will be multiplied by 0·75. For the ratio of 1 : 3, the multiplier will be 0·65: and for the ratio of 1 : 4, 0·58."

Experience shows that belts ought never to be less than 20 millimetres wide, as they are subject to stretching and breakage. Their width should also exceed that ascertained from the table by at least one-sixth. Machines working different materials, with varying quantities, undergo more or less strain. Thus, a spinning mule, after having worked ten hours, absorbs one-fifth more power than at the outset. Wet weather occasions the same effect, while obstructions, want of oiling, materials more or less difficult to spin, &c., are so many causes which have to be neutralized by developing the friction surfaces of the belts.

Loss of Velocity suffered by Belts while in Motion.

"The variable length of the belts has an influence upon their slipping: when they are crossed they are less liable to slip.

"The loss of velocity suffered by belts, when mounted, depends upon their friction surface.

"Long belts are less liable to slip than short ones, for the latter are always stretched in a manner injurious to the journals and

brasses, and notwithstanding this amount of tension, they are still subject to a considerable loss in velocity.

"I have undertaken some experiments in regard to losses of this nature, to which belts are liable, relatively to their lengths, and I have thought it well to prepare a table, for calculating the amount of motion transmitted by belts which no operator can well do without.

Table showing the Slip of Leather Belts relatively to their Lengths.

Parallel belts. Length in metres.	Percentage of velocity lost by slipping.	Crossed belts. Length in metres.	Percentage of velocity lost by slipping.
2	4·2	2	3·5
4	3·9	4	3·2
6	3·6	6	2·9
8	3·3	8	2·6
10	3·0	10	2·3
12	2·7	12	2·0
14	2·5	14	1·8
16	2·3	16	1·6
18	2·1	18	1·4
20	1·9	20	1·2

"Belts, after having served for a certain length of time, and having withstood more or less tension, become greatly impaired by stretching and narrowing.

"The width of belts diminishes in proportion to the strain upon them. Experience shows that on the first day a belt is used it suffers an elongation of one per cent. This action continues to diminish till the third day, after which the belt works on without much change in its dimensions.

"The causes producing loss of velocity in belts are imperfect lubrication of machinery, obstructions in the journal boxes, wheel gearing out of line, inferior quality of leather, couplings and sewing, and oil on the pulleys.

"When a belt slips, the difficulty is remedied by sprinkling the rubbing surface with a mixture of Spanish white and resin. If the belt is smeared with oil, Fuller's earth is employed, which has the property of absorbing greasy substances, and the rubbing side of the belt is then scraped with a wooden blade.

"Very often a badly made knot in a coupling joint will cause the belt to lose one or two per cent. of velocity.

"To transmit and secure the motion to be imparted, the belts are sewed in such a manner as best to insure against their slippage, but as they always tend to elongate, in order to obviate this difficulty, the ends are bound together by a leather thong. These are generally of Hungarian leather, cut into thin and narrow strips, so as to be readily handled, as well as to avoid the necessity of punching large holes in the belt, which greatly lessens its strength.

"The flaxen or hempen thread, intended for sewing belts, ought to be of superior quality, and smeared with some pitchy substance to prevent ravelling.

"M. Hunebelle, of Amiens, manufactures very durable belts, the couplings of which are made of Hungarian leather prepared in some peculiar manner. I have substituted animal substances for thread. I have had good results from eel-skins, and have also tried small cat-gut. My experience has been that the belt of a spinning frame, sewed with this material, may last two years without suffering any deterioration; and the cost of this article is not so great as to oblige us to reject its employment.

"Pulleys should have a rise of one-twelfth of their face width.

"Sometimes, to impart motion to a machine situated at a distance from the transmission, we resort to what is called a binder or carrying pulley which consists of two small wooden drums, having a face convexity of one-twentieth their width, secured to iron axles running in brasses, the whole made adjustable. These drums should never be less than 20 centimetres ($0^{m}{\cdot}20$) in diameter, a large diameter never does harm. This contrivance, which was first introduced by a foreman named Buignet, stretches the belt in every direction."—*A Practical Treatise on the Manufacture of Worsteds and Yarns.* M. Leroux. H. C. Baird, Phila., 1869.

(To be continued.)

An Instructible Metallic Packing as applied by Mr. Girdwood, London, is described in the *Mechanics' Magazine.* Copper wire is closely woven into sheets and then rolled up to a proper thickness; it is now pressed in a square or other shape and bent into a ring, the two ends being brought close together by means of a press, so as almost to unite them. These flexible and seamless rings readily admit of the proper pressure to obtain a perfect joint by the cover screws, and being of metal and unalterable by heat can be used with great advantage for high pressure and superheated steam.

Mechanics, Physics, and Chemistry.

THE GRAPHICAL METHOD.

By Prof. Edward C. Pickering.

One of the most valuable means of studying physical laws is the graphical method, or the representation of phenomena by curves. If any two quantities are so connected that an alteration of one produces a change in the other, a curve may be constructed in which ordinates and abscissas correspond to the magnitudes of these variables. The principal objection to this method is its inaccuracy, and the object of the present article is to show how this difficulty may be avoided, and the errors reduced to any desired magnitude. One of the most accurate applications of the graphical method was that of Regnault, in his study of the laws of heat. He used a copper plate, ·8 of a metre square, and constructed points by means of a miniature dividing engine, giving hundredths of a millimetre, or five places of decimals. Probably, however, the last of these would be very doubtful, and in the printed sheet even the fourth figure is liable to an error of one or two units. Again, it is difficult to draw a curve through a series of points, unless they fall near together, and therefore, in practice, we can hardly depend on more than three places of figures with certainty. That is, if all our points fall between 0 and 1, our errors should not exceed one-thousandth, if between 0 and 100, one-tenth.

The most obvious means of diminishing errors is to enlarge the scale. This is, however, limited by the size of the paper, and has moreover the disadvantage of making the points fall further apart, and thus rendering it more difficult to draw a smooth curve through them. In many cases, therefore, a large curve is no better than a small one. This objection does not apply to the straight line and circle, since they may be constructed by the ruler and compasses, but it then becomes necessary to construct all the points to a scale, as a distortion is almost always introduced in paper ruled or engraved in squares, by its unequal expansion by moisture. The next question is the degree of accuracy as affected by the inclination of the curve to either axis. Generally, after constructing our curve, we

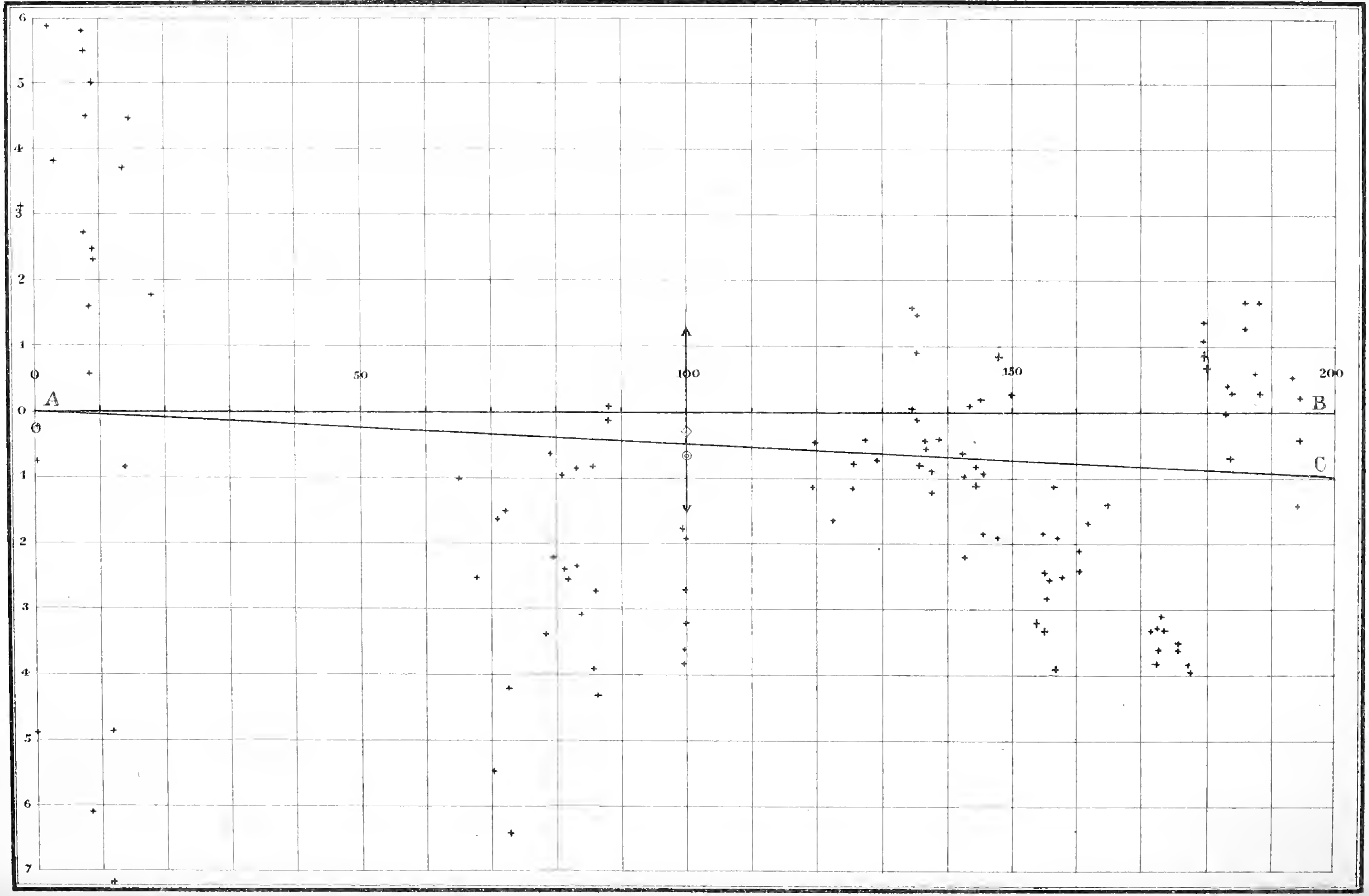
wish to know the magnitude of one variable corresponding to certain values of the other, that is, we draw horizontal lines corresponding to certain assumed values of y, and the abscissas of the points where they meet the curve will give the corresponding values of x. If the curve is nearly horizontal, large errors may be introduced, owing to the obliquity of the intersection, and if nearly vertical, there is the same trouble with the values of y. Now, it is by no means necessary that abscissas and ordinates should be taken to the same scale; in fact, they usually represent different units. By increasing the scale on which abscissas are constructed, we render the curve more nearly horizontal, increasing the scale of ordinates, more nearly vertical. The question then arises with what degree of accuracy can these intersections be found at different inclinations, and what scales must be adopted to give the best results. Evidently, the error will be proportional to the space through which the lines coincide, or to their thickness divided by the sine of their angle of intersection. Calling, therefore, a the angle the curve makes with the axis of X, the error in determining $x = \frac{e}{\sin. a}$, and for $y = \frac{e}{\cos. a}$, e being the error when the lines are as right angles, or its minimum value. When $a = 45°$, the two last errors $= 1{\cdot}4\, e$, the most favorable case. When $a = 30°$, the error of x or $e_x = 2\, e$, $e_y = 1{\cdot}12\, e$; $a = 90°$, gives $e_x = 0$: but $e_y = \infty$, or the point of intersection cannot be obtained since the two lines coincide. One conclusion then is that the scale must be taken such that the curve will not be very oblique to either axis, the best effect being attained with angles of 45°. When the scale is enlarged in one direction only, the accuracy is not proportional to the enlargement, but depends on the direction of the curve. As the direction of a curve is commonly given by the tangent of the angle it makes with the axis of X, let tang. $a = \frac{a}{b}$: then $e_x = \frac{\sqrt{a^2 + b^2}}{b} e$; $e_y = \frac{\sqrt{a^2 + b^2}}{a} e$. If we enlarge the scale of x, m times that of y, n times, we have $e_x = \frac{\sqrt{a^2\, m^2 + b^2\, n^2}}{b\, m} e$.

$e_y = \frac{\sqrt{a^2\, m^2 + b^2\, n}}{a\, n} e$, from which we can readily compute the increased accuracy due to the enlargement in any case.

Let us now suppose that we have a sheet of paper 1 metre square

divided into millimetres, and that on this we have constructed a curve to such a scale that it extends nearly diagonally across the sheet, and that all our observed points agree with theory within a millimetre. It will generally be only difficult to decide whether these errors, although occurring in the fourth place of decimals are real variations from theory or only accidental errors. Moreover, only a very small part of the paper is used, the ruling on ninety-nine hundredths of it being quite useless. We then construct a curve in which while x is unchanged, y represents the deviation between the observed and theoretical curve the scale being enlarged 10 or 100 times. Evidently the errors will now become so large that we can tell at a glance whether they are accidental or constant, and if the latter, how the curve must be altered to diminish them, or by what amount we must correct any point of our theoretical curve to make it agree with observation.

This method has special value in obtaining empirical formulas from series of observations. We assume some simple equation as a first approximation, and construct points as before, giving differences on an enlarged scale. Treat this new curve precisely like the first one, assuming a second approximate equation, and so proceed until all deviations except those of observation are eliminated. Placing y equal to the sum of all these assumed values, (first reducing them all to the same scale) we have the required empirical equation. To put the matter in a mathematical form, let x'' and y'' be co-ordinates of each observed point in succession. Assume the curve $y = f(n)$ which shall nearly coincide with them and construct the points whose coordinates are x'' and $[y'' - f(x'')]\ 10$. As an approximation to this last curve take the formula $y = f'(x)$, and construct again a curve with co-ordinates x'', and $\Big([y'' - f(x'')]\ 10 - f'(x'')\Big)\ 10$. Having finally destroyed the constant errors we have the required equation $y = f(x) + \dfrac{f'(x)}{10} +$ &c. It is best where practicable to assume some simple value of $f(x)$, $f'(x)$, as $a\,x + b$ or $a \log x + b$ making $a = 1, 2, 3, \cdot 5$, &c. Much labor is thus saved and we can often find a simple equation which will satisfy observation as well as any complex one. The examples given below explain this method more perfectly than any description, and show how easy it is to compare different empirical formulas.



Lith. Jas Gurigan, Phila.

A point of inflexion is readily found by assuming equations of the form $f(x) = ax + b$, and making these lines approximately tangent to the curve at the required point. Maximum and minimum values of y are found by drawing the axis of X very near these points and enlarging y.

Asymptotes present especial difficulties to the graphical method as commonly used. Suppose we have a curve asymptotic to the axis of X. Construct a curve in which while y is unchanged x shall be the reciprocal of that previously taken. Then all points of the curve between 1 and ∞ will now be included between 1 and 0. It is often desirable to determine the area included between the curve and asymptote. If this is finite our new curve will be tangent to the axis of x at the origin. Its magnitude may be determined by constructing a third curve in which x is, as before, the reciprocal of its first value, while y for any point is proportional to the area included between its ordinate and that of some other point assumed as an origin. These values of y may be obtained from the original curve by the usual processes of measurement. The ordinate of the point where our new curve meets the axis of y gives the total area required. As an application of this device, see an article by the writer in this *Journal*, March, 1870, entitled "Diffraction along the Moon's Limb."

Of course all these methods would only be used where the application of the calculus is impossible. The true test of the excellence of the devices here proposed is to apply them to some known series of observations, and for this purpose I have selected those of Regnault on the latent heat of steam, its pressure, and on the absolute dilatation of mercury.

I. *Latent Heat of Steam.*—Four series of experiments were made, and from them he concluded that the total heat was best represented by the formula $T = 606{\cdot}5 + {\cdot}305t^{\circ}$. I therefore assumed this as a first approximation, and constructed points as in Plate I. in which temperatures are measured horizontally and the total heat vertically, the unit of the latter being ten times that of the former.

Series I. is confined to determinations very near 100°. Six preliminary experiments give the points represented by crosses. The other 38 are contained between 638·3 and 635·5 or + 1·3 and — 1·5. The square shows the mean of the latter which is 636·73, the circle the mean of the whole 44, or 636·35. The probable errors of these means are ·09 and ·13. The formula giving 637 is evidently too great.

Series II. relates to temperatures between 100° and 200°. The formula again gives too large results.

Series III. gives the measurements between 50° and 100°. With a single exception every point is below the axis.

Series IV. for low temperatures (near 0°) gives very scattering results. They are, however, in general above the axis.

If we simplify the formula of Regnault by substituting ·3 for ·305, so that it shall read $T = 606{\cdot}5 + {\cdot}3t$, we obtain the line A C, which agrees much better with the observations of series I., II. and III., and nearly as well with series IV. Its agreement with series I. is all that could be desired, being less than the mean, if we reject the first six observations, and greater than it, if we retain them. Giving them a weight of ·7 makes the mean coincide precisely with our formula. To show with greater certainty the advantage gained by the change here proposed, I have computed the probable errors regarding the old and new formulas successively as correct.

SERIES.	I.	I.	II.	III.	IV.	All.
Number observations....................	38	44	73	23	22	156
Probable error, Regnault's formula......	·55	·87	1·27	2·00	3·15	1·72
Probable error, proposed formula........	·53	·74	1·07	1·77	3·15	1·60

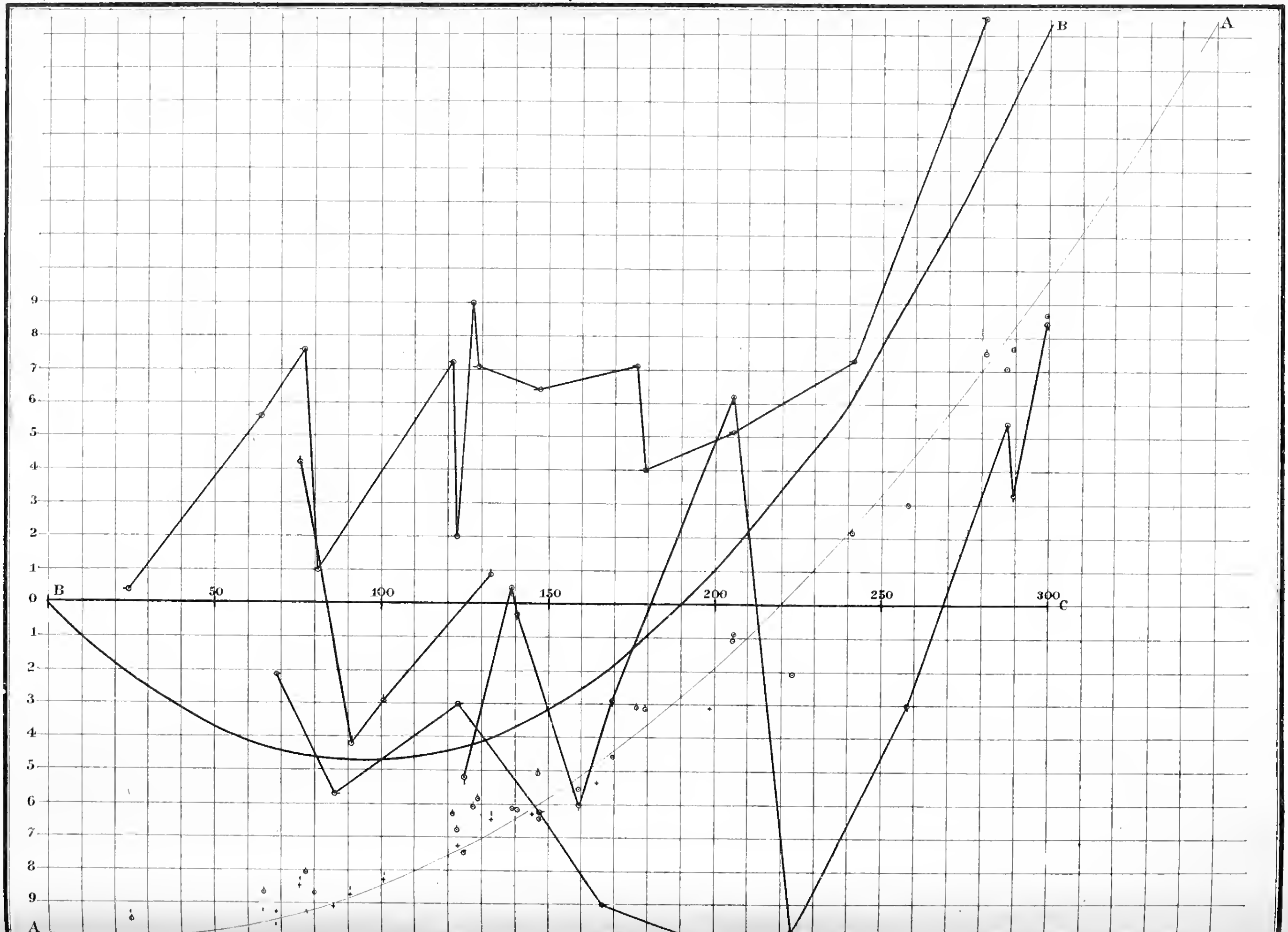
The probable errors according to the new formula being evidently less than the others we conclude that the total heat of steam may be expressed by the formula:—

$$T = 606{\cdot}5 + {\cdot}3\ t,$$

and that the total heat at the boiling point is 636·5 instead of 637 as commonly taken.

II. *Absolute Dilatation of Mercury.*—Regnault gives as the best formula for the absolute increase of volume of mercury by heat. $I = {\cdot}0001790\ t + {\cdot}000002523\ t^2$, in which I is the *increase* of volume and t the temperature. I first assumed the simple equation $I = {\cdot}00018\ t$, and constructed differences to a scale 176 times that of Regnault, (A A, Pl. II.) The points followed approximately a parabola with vertex at the origin, showing that it was necessary to take into account the second power of t. My second approximation therefore was ${\cdot}000002\ t^2$, which gives a result represented in Plate II. I was now

The Graphical Method



Lith. Jas. Mc Guigan Phila.

enabled to enlarge 10 times more than before or 1,60 times which corresponds to a unit about a mile in length. That is, if one column of mercury was one mile long its change in volume would be shown in its true dimensions. The points of each series of observations are connected together giving four zigzag lines for the four series. The curved line R R shows the values computed by Regnault's formula. Series I. is evidently better satisfied by the new formula as every point falls above the curved line. Series II., on the other hand, agrees best with the formula of Regnault. Series III. and IV. agree much better with the axis except for temperatures above 270°. Although there is much uncertainty attending this measurement, yet there seems for these points a decided tendency to rise above the axis.

Computing as before the probable errors, we have:—

Series.	1	2	3	4	All.
Number of observation	4	6	11	14	35
Regnault's formula	3·4	3·8	5·4	5·6	5·1
Proposed formula	2·2	4·5	3·7	5·0	4·3

The unit is ·00001. We see then that every series except the second gives a less probable error, while the much greater ease of computing with, or remembering the new formula is obvious if we write one below the other thus:—

Regnault's formula, $I = \cdot 0001790\ t + \cdot 000002523\ t^2$.
Proposed formula, $I = \cdot 00018\ t + \cdot 000002\ t^2$

If we take our unit of temperature 100° instead of 1° we have $I = \cdot 018\ t + \cdot 02\ t^2$.

III. *Pressure of Steam.*—The principal object of Regnault's researches was to determine this law. He drew a smooth curve through his observed points, and then compared it with several empirical formulas. As he gives the differences in numbers it is difficult to compare them with one another. I have therefore constructed points in Pl. III. in which the horizontal distances represent temperatures, vertical distances, the difference in pressure computed by the formula and that given by the curve. The unit is 1 mm., and the scale below 100° ten times that above.

The exponential formula of Biot was first tried. Log. $F = a + b\,\alpha^x + c\,\beta^x$, in which F is the pressure, x the temperature plus a constant. In equation (F) which relates to temperatures above 100°, $x = T - 100$, in (H) $x = T + 20$, and applies to all temperatures. M. Roche proposed the formula $F = a\,\alpha^{\frac{x}{1 + mx}}$ founded on theoretical considerations and represented by K. The deviation here being greater, the exponential formula was adopted, and by it the common table for the pressure of steam was computed. It will be noticed that certain irregularities are common to all, for instance, at 150° and 200°. These were evidently due to the impossibility of constructing graphically a perfectly smooth curve. As, moreover, the deviation in many cases amounts to one centimetre we see that even the third place of decimals is sometimes doubtful.

The above examples show that it is perfectly possible thus to render obvious the errors even in the most accurate series of experiments, while from a curve we are able to judge with far more certainty of the nature of the errors and the best means of diminishing them, than it is possible to do from the numerical results.

Mass. Inst. of Technology, Nov. 1st, 1870.

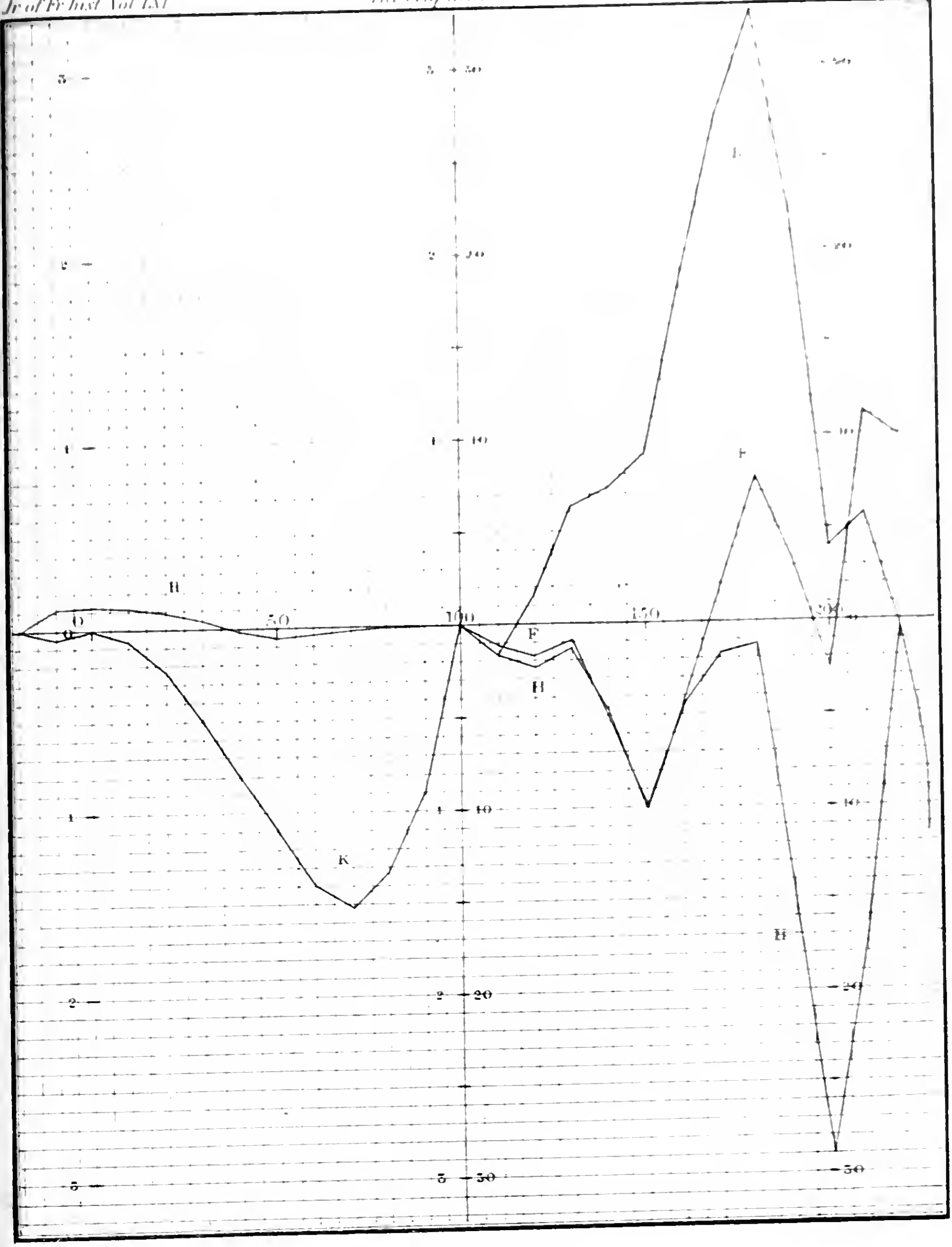
ON THE COMPOSITION OF THE SHELL OF THE LINGULA PYRAMIDATA.

By CHARLES P. WILLIAMS, Professor of Chemistry, Delaware College.

IN 1854, Dr. T. Sterry Hunt first showed * that the shells of the Lingulæ were composed mainly of calcic-phosphate, and that, at least so far as their cinereal ingredients were concerned, they had a composition closely approximating to that of the bones of the vertebrata. The probable relation of fossil species of this genus to the phosphatic nodules found in the oldest members of the Silurian rocks of Canada, was also pointed out by the same chemist. Recently, Prof. W. C. Kerr, Geologist to North Carolina, has ascribed† the origin of the material of the interesting and commercially important deposits of South Carolina, to an existing species of same genus. This species is the *Lingula Pyramidata*, now living in the

* Am. Jour. Science (2) XVII, page 235.

† In a paper read before the American Association, at its August (1870) meeting—an abstract being given in the *American Chemist*, Nov., 1870, p. 180.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shoals along the coasts of North and South Carolina, and having, according to the last named observer, a habitat at the precise level Ashley phosphates.

Some months since, through the kindness of Mr. Geo. T. Lewis, of Philadelphia, I received several specimens of this interesting brachiapod, and have completed two analyses of a sample of their shells. The specimens were from Beaufort Harbor, N. C. The average weight of the detached shells and adhering membrane, in their fresh state, was ·0436 grammes. The samples were carefully dried at 100° C., and the analyses were conducted in the following manner: The organic matters were estimated by incineration and subsequent moistening with carbonate of ammonia and ignition. The hydrochloric acid solution was treated with ammonia and acetic acid, for the precipitation of the ferric phosphate and fluoride of calcium; in the filtrate acidulated with acetic acid, the lime was thrown down as an oxalate, but subsequently converted into and weighed as a sulphate; the magnesian phosphate precipitated in the filtrate by the addition of ammonia, and finally the remaining phosphoric acid separated by adding the magnesian solution. This last precipitate was dissolved, and re-precipitated and weighed in the usual manner. The first precipitate, by ammonia and acetic acid, was analyzed for fluoride of calcium, and separate samples were taken for the carbonic acid and for the sulphate of lime, etc., soluble in water. Annexed are the results:

	I.	II.	Mean.
Organic matters,	41·093	41·580	41·336
$3\ CaO\ PO_5$,	50·753	49·927	50·340
$3\ MgO\ PO_5$,	5·064	5·314	5·189
$3\ FeO\ PO_5$,	trace.	trace.	trace.
Ca Fl.,	·975	·790	·882
$CaO\ CO_2$,	2·411	2·607	2·509
$CaO\ SO_3$,	·208	·098	·153
Chlorides,	traces.	traces.	traces.
Insoluble in acids,	·183	trace.	·091
	100·687	100·316	100.501

In Dr. Hunt's analysis of a specimen of the *Lingula ovalis*, 0·186 grammes lost by calcination 0·072 grammes, which corresponds to 39·24 per cent. of organic matters. The ash gave him 85·79 per cent. of tri-calcic phosphate, which, calculated to the original shell, would give 52·12 per cent.—a result not differing materially from

that obtained by myself for the Lingula pyramidata, and both showing a close approximation in the shell of this brachipod to that of human bone. No estimation was made of fluoride of calcium by Hunt, but in the species analyzed by me the relation existing in apatite, between this substance and the phosphate of lime, was not obtained.

From among the many complete analyses of the Charleston phosphate I have from time to time made, the following (I) is selected for comparison with the result (II) obtained by Hunt, in an analysis of a rounded mass, of a yellowish color, from the Chazy limestone of Hawkesbury, containing fragments of a fossil Lingula, and which had probably resulted from this:

	I.		II.
$3\ CaO\ PO_5$,	60·47		44·71
$3\ Mg\ O\ PO_5$,	2·38	$Mg\ O\ CO_2$,	4·76
$Al_2\ O3 + Fe_2\ O_3$,	2·08		8 60
$Ca\ Fl$,	·70		
$CaO\ CO_2$,	8·34		6·60
$CaO\ SO_3$,	2·89		
$Na\ Cl$,	·62		
Organic matters,	8·56		5·00
Insoluble Silicious Matters,	12·27		27·96
	98·31		97·56

These results, compared with the composition of the possible sources of the materials—the Lingulæ—show that in the process of fossilization the phosphate of lime is not concentrated, but is rather diminished, it may be, either by solution through the agency of the decomposition of the nitrogenous organic matters of the recent specimens, or by decomposition through carbonic acid and subsequent solution. S. P. Sharples,* in commenting upon his analyses of rocks, bearing some analogy to the Charleston phosphates, but obtained by dredging from the Gulf Stream, suggests this same change in the direction of loss of phosphate of lime, and states that the more recent the bone the more abundant the phosphoric acid. Admitting this, the diminished amount of calcic-phosphate in the Charleston material cannot be regarded as militating against the view that its origin may be due to the comminution, alteration and agglomeration of the shells of the Lingula now inhabiting the shoal waters of the coast of North and South Carolina The persistance of these

*Am. Jour. Sciences, March, 1871.

brachipods through all geological periods, from the Potsdam sand stone upwards, in connection with the composition of their testaceous coverings, may give them a significance in the genesis of phosphatic nodules and minerals, not now admitted. They may at least suggest the inquiry in how far other recent deposits of the so-called phosphatic guanos, such as are found on Navassa, Swan, and Sombrero islands may originate from the remains of other Molluscous animals with shells of a composition similar to the Lingulæ.

Newark, Delaware, March 13, 1871.

ON THE USE OF HYDRAULIC MORTAR.

[Translated from "Die hydraulischen Mörtel" of Dr. W. Michaelis, for the Journal of the Franklin Institute.]

By Adolph Ott

It is the peculiarity of all hydraulic mortar, that it hardens under the influence of water, and becomes almost wholly insoluble in the same; it is therefore necessary to make use of it wherever a construction is exposed to the destructive agency of that element, either continually or from time to time.

Hence, this mortar is one of the most essential requisites for all hydraulic constructions, as it would be impossible to erect a durable building under water without having recourse to this cement, unless the use of mortar be abstained from altogether, and large and carefully prepared building stone used instead, which would not require any cementing whatever.

The enormous cost and the difficulties of the latter method would most undoubtedly reduce the number of such constructions to a minimum, and when, for instance, we now see imposing lighthouses boldly defying the threatening pressure of the waves, the mariner might be exposed to all the dangers of the coast without a warning signal or a guiding beacon; where splendid ports, with massive docks and bulwarks, most effectually protect trade and commerce against the indomitable nature of a powerful element, we would probably find no trace of the lively intercourse and international commerce which animate our principal seaports, had not human skill and ingenuity found means to replace by art what nature has either refused or granted only at a few exceptional places.

And even at the latter it is reserved to the hand of man to give

to these protecting agencies all the perfection of which they are susceptible.

For the security of commerce, for coast defence and protection, for the intercourse on our water roads in the interior, and for a thousand other purposes, hydraulic mortar is of the highest importance.

Far from being useful only where nature demands its application, it replaces air-mortar in most, not to say in all instances, with the best success.

This applies especially to the best descriptions of hydraulic mortar, and, above all, to the Portland cement.

The extraordinary hardness which this cement acquires in so short a time, and which, as has been proven by numerous trials and investigations in comparison with other mortars, makes the finished construction appear as if chiseled out of one block and out of one substance, as a monolite, is conclusive proof of the superior advantages of this cement over common lime mortar, wherever solidity and durability are aimed at, especially where a construction has to be finished within the shortest time possible.

Yes, we may safely assert that the use of this mortar for buildings above water has made a remarkable impression on our modern architecture, and has replaced the old stiff and clumsy masses by elegance and boldness of conception.

One need but compare the columns, arches and lofty balconies of the present day with those of former periods, to see how much more ease and freedom characterizes our modern style. It looks as if the architect knew how to inculcate his creation with his genius, yea, as if he had succeeded to free himself, as if by magic, from the fetters of gravitation, to which all matter is inevitably subjected.

This supposed magic power is nothing else but the solidity of the materials at his disposal, mortar and iron.

The first practical application of hydraulic mortar of any description was most probably made during the last century before the Christian era.

Vitruvius, to whose description of hydraulic mortar we shall hereafter refer, speaks of its use in the construction of piers and buildings in moist and swampy localities. From the time of Pliny (who reproduces the report of Vitruvius) up to the fifteenth century, no further mention is made of the use of this material.

During the fifteenth and sixteenth centuries, Leo Baptista and

Paladio Scamozzi, two Italian authors, and Philibert de Lorme, a French writer, have made precisely the same reports as Vitruvius.

Since the latter part of the seventeenth century, the Dutch, the condition of whose country renders hydraulic constructions especially desirable and necessary, have used trass, with the excellent hydraulic qualities of which they had become acquainted. Next to Holland, the application of water mortar was first resorted to in France, and then in England, but up to the middle of the eighteenth century nothing further became known about its use and application than that which had already been familiar to the Romans; for the eminent work of Bélidor ("Architecture hydraulique, Paris, 1753,") contains nothing but the directions given by Vitruvius. Since the end of the last century, however, a lively and general interest in the subject has manifested itself.

The celebrated architect, Smeaton, builder of the Edystone lighthouse, and author of the work published on its construction in 1791, gave a fresh impulse to the experiments with and the universal attention paid to hydraulic mortar. He had to solve the problem of constructing a high and colossal structure, exposed to the tremendous fury of the sea, for which purpose he had to look out for a mortar capable of resisting the influence of water most effectively and lastingly, in order to prevent the rapid ruin of the edifice. For this purpose the various descriptions of English lime were subjected to a careful examination, until he found that the hardening of mortar in water was solely dependent on the proportion of clay it contains: *on its argilliferousness*, and not, as Bélidor, George Semple (1776), and Dr. Higgins (1780) had assumed, on the hardness and denseness of the limestone.

The excellent qualities of Parker's mortar, introduced in 1796, and subsequently called Roman cement, but above all, the invention of artificial cement of decidedly superior efficacy (1822, Girault and St. Leger, 1824, Joseph Aspdin) more especially contributed to the introduction of the hydraulic mortar. The great advantages secured by the use of the better descriptions of these artificial cements are so indisputable that their application is calculated to become more general from day to day.

Hydraulic lime and cement, if to be used as mortar, are mixed either with sand or with some other material serving as a substitute for sand. For weak hydraulic lime, such an admixture is an essential improvement; the weakest descriptions of it would not, in fact, be

of any practical use without it, as, like common lime, they are not in themselves of sufficient solidity.

With cement it is different, however, and we need only call to mind the specific gravity, the structure and the hardness of Portland-cement to explain this.

But if even Portland-cement receives in most cases an admixture of sand, the reason of it is this, that although its hardness is no doubt considerably lessened by this process, it still remains sufficient to afford the necessary security (Portland-cement mixed with three times its quantity of sand becomes in a few months superior to air-mortar more than a hundred years old), while the cost of the material is thus evidently reduced in no small degree. It is also found that Portland-cement is worked with greater ease and security when mixed with sand.

The best admixture is undoubtedly sand. It has been used for that purpose from time immemorial, and it is indeed the best adapted material, as well on account of its nature and special quality as on account of the facility with which it can be procured almost everywhere.

The circumstance that the hardness of any mortar prepared with sand is dependent on the greater or smaller adhesion of the lime or cement to the sand, shows conclusively, that not every kind of sand is fit for the preparation of mortar; that its adaptability for that purpose is dependent on the condition of its surface, on its form and cleanliness. As far as the cohesion of the sand is concerned, clean quartz-sand is preferable to all others, on account of its greater solidity and of its greater power of resistance to the decomposing influence of the weather. From a chemical point of view, however, an admixture of feldspar or other mineral debris, upon which lime exercises its action, however slowly, might be recommended, inasmuch as they cause a slow but constant increase of the firmness of the material, especially when weak hydraulic lime has been chosen.

At Havre, for instance, they use almost exclusively sand composed of flint-detritus, because it has been found that it makes a far better mortar than any other material.

Surfaces which are covered with light dust or with loose claymire always form a great impediment to intimate, close cementing. It is well known that scarcely more than five per cent. of clay are sufficient to reduce the hardening capacity of ordinary lime mortar to a minimum. It is therefore necessary to resort to a careful

washing of all sand which is to be used for the preparation of mortar, and which is not in itself very clean, until the water runs off clear. Sand taken from the bed of a river and sea sand have gone through such a washing process to an extensive degree; these sands are consequently very clean in most cases, and would therefore be extremely well fitted for our purpose, if they had not been ground into smooth round granules through the constant influence of the moving water. Now, it is well known that bodies of a spherical form offer the smallest surface proportionately, and that an aggregate of such globules contains the largest intermediate space. Such sand is therefore of but very little use when we have to look above all to the greatest possible surface, and to the smallest measure of interstices. For this reason, clean, angular and irregularly shaped pit-sand may be considered the best admixture, especially where its surface is largest in proportion to its quantity, and where it almost assumes the form of leaflets, such as are obtained by the splitting of minerals.

As it is desirable that the extent of surface be proportionately larger than the quantity of the sand, fine sand is always preferable to coarse; the latter should never be used alone, but should always be mixed with a sufficient proportion of fine sand to fill up, as far as this can be done, the intermediate space between the coarse granules.

The quantity required for this purpose can easily be ascertained by taking a certain volume of coarse sand, one hectolitre for instance, and by pouring into it water out of a gauged vessel, or from a weighed quantity, until all the intermediate space is filled up, and the water begins to show itself at the surface. The quantity of water used indicates the aggregate intermediate space in the coarse sand. By proceeding in the same manner with the fine sand intended for admixture, the difference in the volume of water used shows the quantum of fine sand required to fill out the interstices in the coarse material. But wherever fine sand can be easily obtained at small expense, such particular measuring may be done away with, as it is better to take at random a larger quantity for admixture.

Coarse sand may be used in larger proportions where solidity and compactness are not especially aimed at; in the construction of foundations gravel and stone debris answer the purpose.

The quality of sand may be easily ascertained as follows:

If good sand is rubbed between the hands, its roughness is felt, and a grating sound is heard.

If spread on white paper or linen, and rubbed smooth, no dirty spots or stains should be visible on the paper or linen.

If shaken in a glass of water, the latter ought not to appear materially troubled.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Meeting, January 18th, 1871.

The meeting was called to order with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting, held January 14th, donations to the Library were received from the Royal Institution of London, l'Academie des Sciences, of Paris; the Geologischen Reichsanstalt of Vienna, Austria; the Literary and Historical Society of Quebec, Canada; Col. J. B. Eads, Chief Engineer of the Illinois and St. Louis Bridge, St. Lous, Mo.; Prof. J. C. Coffin and the Surgeon General's Office, Washington, D. C.; Gen. W. W. Wright, Leavenworth, Kansas; and from Wm. Q. Wharton, Phila.

It was further reported that Samuel Hart and Wm. B. Bement had resigned their membership in the Board of Managers, and the annual report of the Board to the Institute was read.

The Judges of election for the year 1871 here reported that the balloting had resulted in the choice of the following gentlemen as officers, to wit:

For President, Coleman Sellers.

For Vice-President, Robert E. Rodgers.

For Treasurer, Frederick Fraley.

For Secretary, Wm. H. Wahl.

Managers, for three years, Wm. B. Le Van, Jacob Naylor, Samuel Sartain, Chas. Bullock, Enoch Lewis, Wm. Helm, R. Egglesfield Griffith, Ed. H. Williams.

For two years, Hector Orr and Clarence S. Bement.

For Auditor, Wm. Biddle.

The President expressed his gratification at the compliment of re-election and announced the reading of a paper upon the Modes of Determining of Horse Power by Edward Brown.*

The paper provoked considerable discussion participated in by Messrs. Briggs, Le Van and Brown. On motion of the last named gentleman a committe of five was appointed by the President, to in-

* For Abstract of this paper see Vol. LXI., page 187.

vestigate the subject of the paper and to report if possible upon a uniform plan to be followed in the estimation of H. P. The committee consisted of Messrs. Brown, Briggs, Le Van, Cooper, Wahl.

The report of the Secretary on novelties in sciences and the mechanic arts was next read, after which Prof. Morton exhibited a variety of wave and cohesion figures in his newly devised vertical lantern.

The meeting was then adjourned.

Wm. H. Wahl, *Secretary.*

Bibliographical Notices.

Explosion of Steam Boilers. By J. R. Robinson, Steam Engineer. Little, Brown & Co. Boston, 1870.

Mr. Robinson's little book gives us accounts of boiler explosions when caused by low water, overpressure, defect in materials, sediment, and repulsion and overheating of the water in the boiler, and tells us how explosions from these several causes may be prevented. He presents to us some of those "wonderful manifestations of the power of the repulsive action of heat upon water, and of the explosive force of the sudden vaporization of water on the bottom of a steam boiler," witnessed by him during recent experiments, which throw some light upon the dark side of this mysterious subject, and which "also show how a strong steam boiler may be caused to explode at or below the ordinary working pressure, without a sign of trouble with the water noticeable at the surface up to the time of the explosion, and without an elevation of the temperature of the boiler that it would be possible to detect by the most careful examination afterwards," which fact is truly alarming, and the announcement of which should start us at once in search of a remedy.

Mr. Robinson's "report," in a few words, but deserved ones, is written by an intelligent practical man, without spread or bias, and is a clear presentation of facts which have been collected from first-class authorities and from his own experiments, as well as of conclusions drawn from these.

It deserves careful reading and consideration, as the boiler does

management, and we shall not be secure against destructive explosions of steam boilers until we put the best material in them, have them well made, take good care of them, and then study all the particulars of their make, use and behavior, as Mr. Robinson has done, of which this hand treatise is proof. J. H. C.

The Elements of Astronomy. By J. Norman Lockyer, F. R. A. S., Editor of Nature, etc. American edition. Revised and specially adapted to the schools of the United States. New York: D. Appleton & Co., 1870.

We should be glad to see this valuable little volume of Mr. Lockyer's thoroughly domesticated with us. The subject is well divided, and his descriptions interesting and happily worded. It is well up to the astronomy of to-day, for we find incorporated in it the discoveries of recent eclipse observers and the marvellous revelations of the spectroscope. It is amply illustrated with admirable wood-cuts, and is altogether eminently fitted to occupy the place for which it is intended, as a text book in our schools.

Galvanic Battery with Nitric and Chromic Acids.—On page 376 of our 59th volume we published an account by Mr. W. P. Levison of some observations which he had made on the beneficial effect of nitric acid, when added to the bichromate solution now so much used in the Bunsen battery.

We see in the last number of *Silliman's Journal* that Mr. S. P. Sharples has made a thorough investigation of this subject, taking the resistance and electro-motive force of various couples, and has come to the conclusion that the best composition for this purpose is prepared by saturating nitric acid with potassium bichromate at a moderate temperature, adding one-third volume of sulphuric acid, and then adding water enough to re-dissolve the precipitated chromic acid.

A cell charged with this fluid about the carbon has the same electro-motive force as an ordinary Bunsen; an internal resistance but fifty per cent. higher is sensibly constant for twelve hours and gives no fumes.

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FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. LXI.] MAY, 1871. [No. 5

EDITORIAL.

ITEMS AND NOVELTIES.

Boiler Explosions.—In Prof. Thurston's able paper, continued in our last number, allusion is made to the good effects of the steam boiler inspecting and insurance companies of England, and to the marked benefits which had resulted from their labors. We see in the last number of the *Mechanics' Magazine* that, in the report of the Manchester Steam User's Association for 1870, which has just been read, it appears out of 2116 boilers under inspection, no explosion has occurred, while of boilers not under inspection, 51 have exploded, killing 78 persons and injuring 106 others. It is certainly high time that this preventable loss of life and limb should be arrested.

In further illustration of the fact that even in popular estimation boiler explosions are beginning to be recognized as the result of preventable conditions, and are no longer to be regarded as inevitable

disasters of mysterious origin, we quote from the *New York Times* the following remarks:

"The explosion of a steam boiler is *prima facie* evidence of carelessness in its construction, or in its use. It is so regarded by the engineers, and ought so be regarded by the law. It will be easy to convince any one who will examine the records of boiler explosions and inquire into the means of preventing them, that no injustice would be done to the owners of boilers by indicting them for criminal carelessness in all cases of explosion.

"The history of boiler explosions is authentic and definite. The boiler has usually been erected under the full light of modern science. All the attending circumstances of the explosion have been immediately communicated to the public; curiosity has aided science in making every man an investigator of these circumstances and a searcher after causes; public and private commissions have been appointed to examine the subject generally; numerous legal tribunals have gone to the bottom of special cases, and innumerable private professional observers have witnessed results, searched records, weighed evidence, and arrived at general conclusions. All the plausible theories of explosions have been not only looked into, but worked out, in many cases, experimentally or theoretically, to their ultimate limits.

"Now, the remarkable and unprecedented result of all this investigation is, not the division of any large body of experts into schools; not the building up of rival theories, but the universal conviction of all concerned, that boiler explosions are certainly in most, and probably in all cases, the result of malconstruction or maltreatment, and of nothing else, and that the usual immediate cause is the unchecked deterioration of the boiler in service. In the great majority of cases the evidences of carelessness are as plain as the time of day on the face of a clock—a sheet furrowed nearly through; a stay bolt rusted off; a crown-sheet insufficiently supported; expansion and contraction unprovided for; water connections stopped up; bad material—some one of the many obvious and certain conditions of rupture. In a few cases the immediate causes are not apparent, and then the electricity theorists, and the gas people, and the mystery men fight over the remains in the newspapers; and the only reason why simple neglect is not discovered to be the cause, is that the parts of the boiler which would otherwise reveal it, are blown away, or are too much mutilated or obstructed to be legible. Sim-

ple bad treatment by the maker or user will account for the original rupture which ends in any explosion, however terrific may be its effects. There is force enough restrained within every steam boiler running to-day to perform the most terrible work of ruin that any similar boiler ever performed in exploding. When this force is once released, the amount of destruction depends on the point of rupture, the resistance, the surroundings, and on an infinite number of circumstances, mostly outside of our control. The only thing we can do, and it is enough, is to keep the resistance superior to the normal pressure.

"Now that the causes of boiler explosions are so well understood as to be a matter of commercial calculation—where companies make money by insuring such boilers as are constructed and maintained according to established professional rules—it is to be regretted that the government should stand helplessly by, and see scores of people scalded to death every few weeks, for the want of an adequate law and a system of inspection. Boiler insurance and inspection companies—and they are no new or experimental thing—simply prove that boilers constructed and maintained according to certain well known rules, are practically safe; that the chances of explosion, even with ordinary water-tending, are very remote, and they stake their money on this knowledge; and yet the United States Government has been unable to check the increase of these disasters. If Congress cannot at once provide for the security of the public against boiler explosions, it had better let out the job of protecting its citizens to some insurance company, and then it will be done on scientific principles, and by competent men."

Steam Boiler Inspection.—The second annual report of the Inspector of Steam Engines and Boilers for Philadelphia, which has reached us through the kindness of the editors of the *Sunday Times*, affords, in connection with the preceding item, additional matter for reflection. We learn from it that during the year 1870 there were upwards of one hundred disastrous explosions of steam boilers in the United States, by which three hundred and twenty-six persons were killed, and two hundred and twenty-seven wounded. Those who were instrumental in calling this Department into existence should be gratified when they are informed that, during the same year, although there were at least two explosions every week in various parts of the United States, of which New York, Baltimore, Brooklyn and Chicago had their respective shares,

none occurred in the city of Philadelphia, notwithstanding the fact that it has a greater number of boilers than any other of the above mentioned cities.

The following paragraph, embodying some excellent views on the qualifications of engineers, is worthy of the widest publicity:

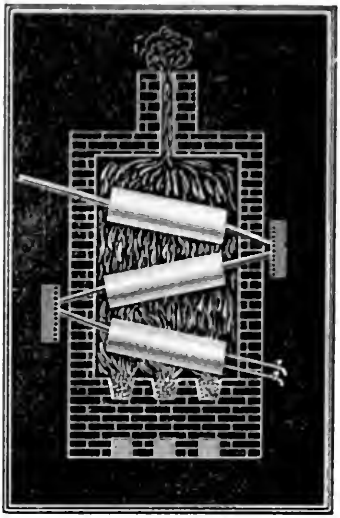
"The bill recently introduced to the Legislature, requiring persons in charge of stationary steam engines in this city, to pass an examination before a competent Board, is a very proper movement, and should receive favorable consideration. The present bill may not be all that is desired in its provisions, but in principle it is correct, and the mere details of the bill can be so amended as to give us a law that will be satisfactory in its construction and beneficial in its operations. A man in charge of a stationary steam engine, driving machinery requiring the labor and attention of hundreds of industrious operatives, has a vast responsibility, involving life and property, and should be required to demonstrate his fitness and capacity for the duties of an engineer. It frequently happens that men are employed as engineers who have no idea whatever of the mechanical intricacies of an engine, and whose knowledge of machinery does not extend beyond the lever by which its motion is regulated. Some trifling defect, which an educated mechanic would instantly perceive and immediately correct, might be permitted to pass without notice by an inexperienced and ignorant person, and result in a terrible catastrophe. In many cases the owners of mills and factories regard the amount of wages to be paid for running the engine as the primary consideration, and never give a thought to the hundreds whose lives are thus wantonly exposed to his cupidity and his engineer's ignorance. The public cannot be too securely guarded against the dangers by which they are constantly threatened through the employment of ignorant and incompetent men as engineers."

The Mont Cenis Tunnel.—One of the most difficult of modern engineering undertakings is now practically finished, and a review of the work accomplished will give a general idea of its magnitude.

Mont Cenis, through which the tunnel has been bored, is, at its most elevated point, about 12,000 feet in height, and separates the French province of Savoy from Piedmont in Italy. The tunnel is very nearly 8 miles in length, its width is 25 feet, and height 24 feet. The character of the rock through which borings have penetrated was variable in different parts—consisting of schist, quartz and limestone; mainly, however, of the first.

The work, commenced in 1857, has been energetically carried on since then without interruption, the mean daily progress having been about 5 feet. The tunnel route will furnish an uninterrupted railway communication between the north of France and the south of Italy, while the port of Brindisi, its southern terminus, is the place of departure and arrival of steamers to and from the East, through that other marvel of engineering perseverance, the Suez Canal.

An Old Invention.—"Before this period a Wm. Blakely, by a new application of Savery's engine, for which he obtained a patent, proposed to employ the expansive force of steam. This is the first plan for raising water by *strong* steam and by an easy transition to do anything else. The following sketch is taken from the author's small tract on the subject printed in French at the Hague in 1776."—*Treatise on Mechanics by Olinthus Gregory, London,* 1815.



The above is an early example of a shell-less, tubulous boiler, the type of numerous modern steam generators.

J. H. C.

Improvements in Safety-Lamps.—Several advances in this direction have lately appeared in our contemporaries which seem worthy of notice. Mr. W. Simpson has devised a self-extinguishing arrangement to accompany the lamp. It is designed to burn paraffine oil, which, as it affords a very brilliant light, is supposed partially to remove the incentive to remove the wire cage. Should the attempt be made to open it, it at once brings into action an automatic extinguisher, which consists of two small metal plates that fall upon the wick and its holder. The fall of the plates is caused by a spring which is released on unscrewing the cage from the lamp. A magnetic lock has likewise been designed by Mr. S. P. Bidder for use with the safety-lamp. This is so arranged that the bolt can only be withdrawn by the action of a powerful magnet, a strong electro-magnet is therefore permanently fixed in the lamp cabin.

As the collier could hardly carry with him without detection an instrument powerful enough to open it, the contrivance would seem to add considerable to his safety.

The Root Blower seems to be meeting with great success abroad as blast supply for cupola furnaces and also in many cases to take the place of the ordinary fan. They are used in a number of Bessemer works and some forty have been recently put up at different works near Glasgow, while in all, over three hundred are in operation throughout the country.

Proportion of Sliding Surfaces.—We see a reference in one of our contemporaries to the fact that if sliding surfaces are equal to each other they will wear true and straight, while if one is smaller than the other the smaller will wear convex and the latter concave. The reason of this is obvious on a little reflection. In the case of equal surfaces the wearing action will be greatest on the parts which are always in contact and will diminish to the outer extremities. As, however, the conditions are identical for each surface this will tend to make both concave, by which the bearing will be brought upon the ends until these are reduced to a normal condition. With unequal surfaces, however, the longer becoming concave through the greater wear of its middle portions, the shorter grinds away to fit it.

Railway Ties in South America are mostly obtained from California, as the hard wood ties cut on the Andes cannot be used without boring the spike holes with augers. The original cost of a tie cut at San Francisco being 40 cents, the additional freight and commission make it quite expensive, being one dollar at Callao.

A Pneumatic Despatch Tube.—An experiment designed to greatly facilitate the rapidity of delivering telegraphic messages is now being tested in the city of London. The continually increasing use made of the local telegraph, and the constantly increasing distance between the extremes of the business quarters, have rendered some other plan than that of delivery by messenger from the main office necessary. The messages as they arrive are sorted, and those intended for delivery a mile or more from the office are enclosed in a light cylinder, which is placed in a tube leading to a branch office in the neighborhood to which the messages are directed. The tube being properly closed, a strong current of air is blown into it behind the cylinder, and it is forced through to the branch office. Shunts are provided so that the carrier may be sent in any direc-

tion, the intermediate flaps being closed to allow it to pass. As to the time in which the delivery can be made, the *Mechanics' Magazine* states that a distance of 2058 yards between the offices was travelled over in about four minutes. It is said, thus far, to have been perfectly satisfactory. A plan of this kind might be very usefully instituted to facilitate the delivery of the mail of large cities. The letters, upon delivery at the main office, could be sorted, and sent rapidly to the several receiving offices, which might be of simple character, and judiciously increased. By this means the delivery of letters might perhaps be effected in a fraction of the time now required, thus contributing materially to public convenience and business interests.

The Effect of Cold on Iron and Steel.—It is somewhat surprising that a question of such paramount importance as the one heading this notice should still remain without the authoritative decision of that investigation of which it is worthy. Within the past few months several papers have appeared treating more or less elaborately of the subject, but far from setting the matter at rest, the experiments have led their authors to very contradictory results.

The general course of the experiments was that of selecting suitable pieces of cast and wrought iron and steel, and placing half of the number of each variety in a freezing mixture while the others were kept at the ordinary temperature. A cold and warm piece of each kind were now alternately subjected to a transverse strain and the amount of weight required in each case to break them was noted. The effects of a sudden blow were likewise noted by allowing a weight to fall upon the pieces from varying heights. The investigations of Sir W. Fairbairn and Dr. Joule declare that temperature has little or nothing to do with the strength of the metal. The breaking strain, indeed, was found to be slightly greater in the cold than in the warm specimens. These comprised both wrought and cast iron and steel. The results of Mr. Peter Spence obtained with cast iron bars even indicate that reduction in temperature increases the strength of the material. Mr. W. Brockbank, however, who has expermented with cast iron bars declares for his result, that cast iron suffers a considerable diminution in strength and elasticity when the temperature is reduced below the freezing point, a decision precisely opposite of that arrived at by his fellow-investigators, pursuing the same general method of inquiry.

The explanation of this incongruity we have little hesitation in

assigning to a constant and neglected source of error in the mode of conducting the research, which must, until proper weight has been assigned to it, render the announcement of any general conclusion hazardous and unreliable. This source of error resides in want, or rather the entire absence of attention bestowed on the chemical character of the materials employed. The very important influence exerted upon the quality of iron, and especially upon those very properties, the conditions of which are being discussed, by the presence, in greater or less proportion, of phosphorus and sulphur is too patent to be more than mentioned; and for aught that has been shown to the contrary, the brittleness and tenacity of each variety as the temperature diminishes may be either increased or diminished according to its chemical composition. This, indeed, in view of the evident care in which the investigations mentioned were conducted, as might have been anticipated from the character of their eminent authors, seems to be the most rational method of accounting for the contradictory nature of their conclusions.

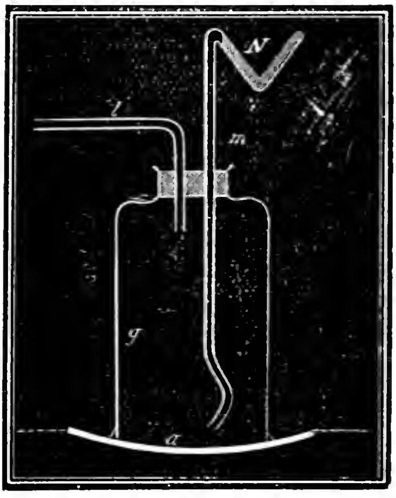
Until, therefore, investigations are conducted with irons of different quality, and an accurate analysis of each shall accompany the same, the question must still be considered an open one.

An ingenious application of the Spectroscope.—We learn from the *Quarterly Journal of Science* of a most ingenious use of the spectrum analysis, which will doubtless suggest the usefulness of extending its application to the elucidation of many inquiries, where it has heretofore not been appealed to. The case referred to is substantially as follows: The water used by the inhabitants of a crowded court, amongst whom several cases of typhoid fever had appeared, was drawn from a rather shallow well, and was highly charged with various unoxidized compounds of nitrogen. It was suspected that, from some defect, the contents of a public urinal obtained entrance to the well. The fact that the well-water contained seven times as much common salt as the normal water of the vicinity was some confirmation of the suspicion. Prof. Church obtained absolute proof by the following method. He introduced two grammes of a lithium salt into the urinal, and, two hours later, was enabled readily to detect with the spectroscope the presence of lithium in a litre of the well-water, which by previous examination had shown no trace of this substance.

Corrugated Flames are described by E. Villari in *Pogg. Ann.*, from an interesting experiment. Approach a tuning-fork vibrating

horizontally to an ordinary gas flame, so as almost to touch, and the volume of tone will be largely increased, showing that the flame takes part in the vibration, although it presents no marked change in appearance to the unaided eye. To make the vibrations visible, take a card disk, kept in uniform rotation by wheelwork, and provided with 16 slits each, 2 to 3 millimetres wide and 7·5 long, and place this from 8 to 20 inches from the gas flame. To prevent the currents of air produced by it from disturbing the flame, a glass plate or large card having a large horizontal slit is placed between the flame and disk. On looking at the flame through the descending horizontal slits, it is immediately broken up into alternate bright and dark bands, running horizontally across. The position of the tuning-fork is of no particular consequence as long as it is near enough, and even the sounding case of an actively vibrating fork may be used. In this case the wavy flame can often be seen directly, without the aid of the rotating disk.

A New Experiment.—In the phenomenon of the spheroidal state, the globule will float when the vapor beneath it is able to support the pressure of the atmosphere plus the weight of the globule. If we remove the former factor, a much smaller vapor-tension will be required to produce the phenomenon, as may be proven by the following experiment, described by E. Budde,* in which, with the aid of the air-pump, a Leidenfrost globule is supported upon a metal plate whose temperature is below 100° C. A bell-shaped glass vessel, *g*, is firmly cemented to a copper plate, *a*. Through the stopper which closed the upper opening, pass two glass tubes, *l* and *m*. The first attaches by caouchouc tubing to the air-pump. The second reaches within the vessel nearly to the plate *a*, while above, it is closed and bent into an N form. The bent portion is filled with water. The plate is now placed upon the water-bath, which soon imparts to it a temperature of from 80° to 100° C. The air-pump is now put in operation; the water in *n* evolves air-bubbles and vapors (gentle heating will facilitate the



* *Pogg. Ann.*, CCXVIII, 158.

operation) which mainly accumulate in the upper end of the tube—and force a portion of the water through m. The water falls boiling, or very nearly so, upon the plate beneath, the temperature of which is, under the abnormal conditions, considerably above the boiling point of the water—and all the conditions necessary for the production of the spheroidal state are present. If the rarefaction is carried until the barometer indicates $10^{cm.}$ (about 4 inches) of mercury, and the water-bath is heated to about 90° C., the experiment will succeed without the slightest difficulty, and the spheroids obtained will evince an energetic movement.

The experiment is not a mere physical curiosity, but possesses an importance which our educated readers will doubtless have already appreciated, inasmuch as it is decisive in confirming the theory of the spheroidal state. It proves that the force which sustains the globule obeys the laws which govern the tension of vapors.

Vanadium.—From Prof. Roscoe's recent investigations upon Vanadium and its compounds, which comprise about all the literature extant upon the subject, we are able to condense the following concerning the preparation of the metal and its properties. It is obtained by reducing one of the chlorides (free from oxygen) in a stream of hydrogen, either with or without the aid of sodium. It is a matter of the greatest difficulty to obtain the metal entirely free from oxygen, since at red heat it absorbs this element with the greatest energy. The entrance of every trace of air or moisture during the reduction must therefore be most carefully avoided; but owing to the length of time required for an operation (40 to 80 hours, according to the quantity of chloride), and the trouble of freeing the chloride entirely from water and oxygen, the attempt to obtain the pure metal is attended with unusual difficulties. A platinum boat is placed within a tube of porcelain, and the reduction effected in this. A greyish-white powder with silvery lustre is the result. It is unchangeable in air or in water, even when heated to 100° C. It may be heated in hydrogen to redness without fusing or volatilizing; when the powder is thrown into a flame it burns with the production of brilliant sparks; when rapidly heated in oxygen it burns to vanadic acid, and heated slowly in the air, it begins to glow, and a sub-oxide is formed, which passes by a succession of steps into the acid. It is insoluble in hydrochloric acid, but is readily dissolved in sulphuric acid. Nitric acid attacks it vigorously. Its specific gravity is 5·5.

Anomalous Spectra.—Kundt has found that besides red aniline mentioned in the last number of this *Journal*, almost all bodies, which in a solid state show distinct superficial colors different from, and generally complementary to, those by transmitted light, give in concentrated solution anomalous spectra. Among these are all kinds of aniline blue, all of aniline violet that have been examined, aniline green (Hofman's green), indigo dissolved in fuming sulphuric acid, indig-carmine, carthamine, murexide dissolved in potash, cyanine, permanganate of potash and carmine. In all these red light is more refracted than blue, and in those which are mainly green by reflected light, if enough of this color is transmitted to appear at all in the spectrum, green is always least refracted. Cyanine, aniline blue, aniline violet and indig-carmine give the colors in the order, green, blue, red; cyanine is the best for these purposes and under favorable conditions gives the spectrum, green, light blue, dark blue, a dark space, red and an indication of orange. To obtain these results very concentrated solutions are required; for dilute solutions give only the ordinary spectra. To make the prism put a drop of the solution upon a piece of mirror-glass and press against it a similar piece with a sharp edge, at an angle of about 25°. It is only immediately at the angle that any light can be made to pass through these highly colored solutions.

Galvanic Engines.—We noticed in a late number of the *Chemical News* a quotation from one of our American journals, in which Mr. Highton's curious misconceptions and unsound deductions are connected with the reported miraculous performances of a galvanic engine at Newark, N. J. We see that at last Mr. Highton's errors are being noted and pointed out in the pages of the *Chemical News*, and we feel well assured that the time is not far distant when the perpetual-motion machine at Newark will reveal the true origin of its force, but in the mean time it may not be uninteresting to notice a fact or two which has a bearing upon the latter.

On page 410 of our last volume will be found a conclusion reached by Prof. Mayer after careful experiment, that "in a combination of spirals or in a helix the inductive action of the wire on itself, or of adjoining spirals or turns upon each other, has no effect upon their power of magnetization."

This evidently bears directly upon the claim that, by introducing a sheet of tinfoil between the successive layers of insulated wire;

wound on an electro-magnet, the power of the same was largely increased. It might, however, be objected that in the experiments of Prof. Mayer, copper disks were introduced between successive spirals, and not cylinders of conducting material between successive layers.

We have therefore made the experiment in this form, using the form of apparatus described by Prof. M. for comparison of strength in the magnetized cores, and found that when tinfoil was introduced exactly in the manner described by those claiming advantage from its use, no improvement whatever could be observed. H. M.

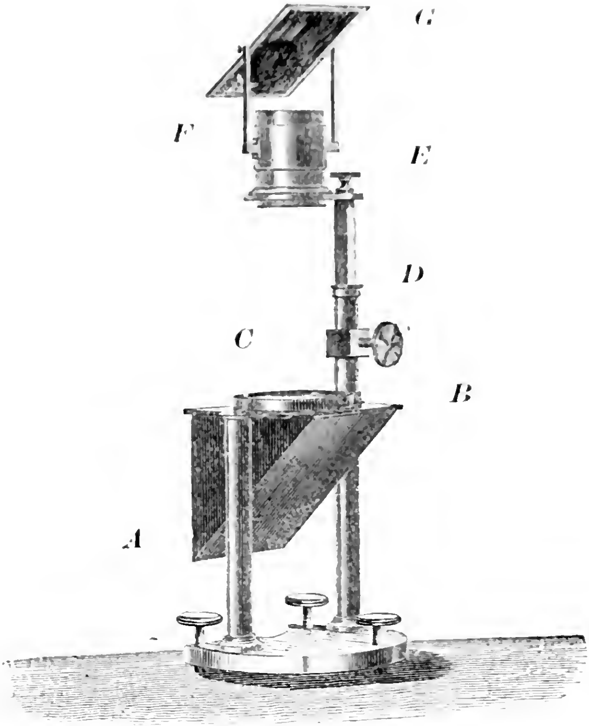
The Vertical Lantern.—At a late meeting of the Franklin Institute, Prof. Morton exhibited a new instrument which he had lately devised, and which, by the beauty and singularity of the effects it developed, elicited many expressions of approbation. The object aimed at was to produce on a vertical screen enlarged and brilliant images of objects which require to be maintained in a perfectly horizontal position, such, for example, as waves in a tank of water, cohesion, figures of oils, and other liquids, magnetic spectra and the like.

In a few introductory remarks the Professor observed that many efforts, attended with more or less success, had been made before with the same objects in view; thus Faraday and Tyndall had turned an electric lantern over on its back, so making the condensers horizontal, and the object being placed upon them, its image was either projected on the ceiling or reflected to the wall. The inconvenience of this plan was, however, very great, as would readily be perceived.

His attention was first drawn by Prof. Cooke, of Cambridge, to another plan which that gentleman had employed for several years. In this case the lantern stood in its usual position, and a mirror placed in front at an angle of 45° reflected the light upwards through the horizontal object and object-glass, beyond which a mirror, silvered on the outside by Focault's plan, reflected it to the screen.

The difficulty here, however, was that the object being removed to a considerable distance in front of the condensers, a very much discolored and unsatisfactory field of light was obtained on the screen. So that the many beautiful experiments with waves, &c., which the Professor had developed, lost somewhat of their effect. To meet this difficulty the speaker had therefore constructed the instrument as follows:

The lantern condenser in the first place was made of three lenses, the first two of such curve as to give, with the light at about two inches from the nearer one, a practically parallel beam, which was received upon a mirror, AB, at 45°, and after reflection from it fell upon the third lens placed horizontally at C, which concentrated it on the objective at E, from which it passed to the mirror FG, which in turn threw it on the screen. This mirror, moreover, was not silvered on the exterior surface but in the usual way on the back, though with pure silver, and yet no want of definition was to be



perceived in the image, owing no doubt to the fact that the faint reflection from the first surface was inappreciable in comparison with that from the metallic silver. In several articles published in the *Chemical News* and elsewhere, a square prism had been described as being used for the purpose, but a little thought, or still better, a moment's experiment would show that this means would not answer, because about one-third of the cone of rays entering the prism would be at too great an angle for total reflection, and would thus

leave one-third of the field dark. The instrument had been constructed by Messrs. Hawkins and Wale, to whose judgment and workmanship it did great credit. The apparatus was then put in operation, being illuminated with the lime light, and there was first shown a magnetic spectrum. Iron filings being evenly scattered over a plate of glass, a small steel magnet was placed beneath, and the glass lightly tapped with a pencil point, when the filings arranged themselves in the graceful inflections of the magnetic curves. A tank of water was then introduced, and by means of an ingenious contrivance devised by Messrs. Hawkins and Wale, series of waves were developed, and their reflections from the sides of the tank, interferences and other phenomena were beautifully exhibited. The apparatus for producing the waves consisted of a metallic box with a sheet rubber cover, provided with a long thin metal tube; this was so placed that the tube was about one-quarter of an inch above the point in the tank which it was desired to make the centre of the wave motion. On tapping the rubber diaphragm a momentary puff of air was driven from the tube, producing exactly the disturbance needed. An elliptical ring being placed in the tank, the properties of the curve with regard to reflections were very neatly exhibited, and, in fact, independent of their scientific interest, nothing could be more charming than the pearl gray waves crossing and interlocking and combining in complex patterns, which ran across the screen.

Cohesion figures produced by letting fall drops of ether, alcohol, carbolic acid, oils of cinnamon, coriander, cloves, etc., on the surface of water were then exhibited, and attention was directed to many other experiments, such as the electric decomposition of metallic solutions, sound figures and the like, for the exhibition of which this instrument was especially adapted.

Discovery of a Bone Cave.—In the limestone quarries of Port Kennedy, Pennsylvania, the workmen exposed what was once a cavern, at the junction of this rock with the new red sandstone. An examination of the same by Mr. C. M. Whately has resulted in securing the remains of no less than 47 species of post-tertiary animals, plants and insects. Amongst the first were found representatives of many of the gigantic forms of that time, including the mastodon, tapir, the large sloths, megalonyx and mylodon, a species of horse and several bears. Many of the bones and teeth were well preserved. The discovery is an unusually interesting one to the palæontologist as affording the first instance in our state of a bone cavern containing such extensive relics of the larger extinct quadrupeds. Mr. Whately has communicated to *Silliman's Journal* (April, 1871) a detailed account of his interesting discovery to which we refer those of our readers who desire further information on the subject.

Editorial Correspondence.

SUEZ CANAL.

The following communication from Prof. J. E. Nourse, which arrived to late for incorporation with his interesting paper in our last number on the Suez Canal, will be found to contain the fullest confirmation of his assertions concerning the immensely growing importance of traffic through it, while it earnestly calls attention to the condition and possibilities of American enterprise in this direction.—Eds.

Dr. W. H. Wahl:

Dear Sir—Since sending the article on the Canal, I have been favored with the sight of an important and recent despatch from the U. S. Consul at Port Said, which I subjoin in the form of an almost literal copy. Yours, &c., J. E. Nourse.

Consulate of United States, Port Said,
January 14, 1871.

Hon. W. Hunter, *2d Ass't Sec'y State:*

Sir—In my enclosure in a former dispatch, I had the honor to invite attention to the large increase of traffic through the Suez Canal—no fewer than *seventy-two* steamers having passed from sea to sea in the month of December, 1870, against *nine* only during the same month in 1869.

Of the 72 steamers, there were the following flags, viz:

British	39.	Registered Tonage	[illegible]
Turkish	12,	" "	7·531
Australian	7,	" "	6·141
Egyptian	6,	" "	3·090
French	6,	" "	7·870
Italian	1,	" "	508
Dutch	1,	" "	150

These ships are employed in the trade between the British, French, Italian and Dutch ports, with the coasts of Arabia and Persia, and with China, Japan and the Islands of the Pacific. There were 4 monitors from England, 2 for Bombay and two for Australia, to be stationed there.

As the result of my observations on the new resources developed by the opening of the Canal and the establishment of this port, I

beg leave to state that I find great encouragement for our American ship owners to establish a line of ships between our ports and India and China via the Canal. Port Said is now one of the most safe and accessible harbors in the Levant, with a perfectly straight entrance from the sea and *twenty-eight* feet of water in the channel.

Apart from the countries east of the Cape of Good Hope, a large amount of freight might be obtained for the United States, composed of gum and coffee from the Arabian coast, wool from the coast of Syria and the Euphrates, fruit from Smyrna, and tallow and lead from Odessa; with all of which places Port Said is in constant communication by steam; not to mention the miscellaneous contributions that might be brought by the regular line of steamers from Trieste, Greece and Constantinople.

If something is not soon done by our merchants, it is certain that the whole trade between the United States and the Levant, as well as of India and China, will pass under the British flag and be conducted through British ports by British merchants.

As a striking instance of the effect of the neglect of Congress to take some steps for the protection, or rather revival of our shipping interest, a few months since a large steamer, built in Glasgow upon the plan of our river steamers, passed through the Canal, bound for China, where she is to be employed in the river trade. During some years past many of the steamers of this class have been ordered from America, but this is the first one built abroad for foreign order; and we are in imminent danger of losing the advantage which has hitherto been a *quasi* monopoly of our merchants, derived from the construction of a class of vessels in every respect so peculiarly *American.*

(Signed) C. R. PAGE, *U. S. Consul.*

Cornish Engines.—*Errata.*—The following errors have inadvertently crept into the several papers on the above subject, by Mr. West. Our readers may correct the same by the references given below.

Last paragraph, page 24, January, 1870, instead of "imperfectly *constructed* experiments, read imperfectly *conducted* experiments."

First full paragraph, page 176, March, 1871, instead of "the friction is increased *inversely*, read "the friction is increased *immensely*."

Last paragraph, page 179, March, 1871, instead of "the Fowey Consols engine Rowan's," read "The Fowey Consols engine *and* Rowan's."

Civil and Mechanical Engineering.

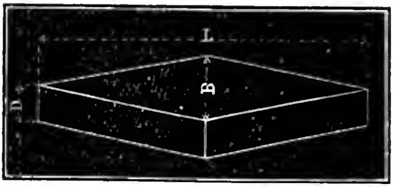
AN EXAMINATION OF SOME EXPERIMENTAL FACTS BEARING UPON THE PROPER RATIO OF THE LENGTH AND BREADTH OF STEAMSHIPS.

By Alban C. Stimers, Naval Engineer.

(Continued from page 266.)

To solve this, let us suppose five ships built of iron of the most approved construction, having the proportions and co-efficients of performance of the five classes just examined; let each have a cargo carrying capacity of 3,000 tons, and a speed which will achieve the distance of 3,000 miles in 10 days; and let them be of equal stability and strength.

It will first be necessary to determine the proportionate weights of hull for equal displacement, when the proportions of the different classes are employed. The best ships are now built on the theory that they are great hollow beams, having at least one deck of iron to form the *upper flanch*, while the bottom corresponds with the *lower flanch* and the sides the *web*. For convenience of comparison, let us suppose the vessels to have the simple form of a double wedge as in the annexed figure.



The proportionate lengths and breadths being already fixed upon, it is necessary to make the depth in each case such that the vessels will have equal stability.

$$\text{Let } L \times B \times D = c, \quad \ldots \quad (1.)$$

$$\frac{L \times B^3}{D} = s, \quad \ldots \quad (2.)$$

$$\text{and } \frac{B}{D} = h, \quad \ldots \quad (3.)$$

The contents of the vessel represented by c (formula 1) is a uniform quantity in all the classes by the postulate, and where c is maintained uniform, s (formula 2) and h (formula 3) will be uniform quantities with vessels having equal stability.

Mr. Scott Russell in his great work on *The Modern System of Naval Architecture* describes an iron steamer, the *Annette* (pp. 375 and 618) which he commends as an example illustrating the advantages of the longitudinal system.

In this vessel it appears that the iron devoted to the longitudinal strength of the hull was 18·4 per centum of the displacement, and that devoted to transverse strengthening 3 per centum.

The proportions were such that—

$$\text{If } B = 1,$$
$$\text{then } L = 6{\cdot}33,$$
$$\text{and } D = {\cdot}6.$$

Employing these proportions and the corresponding weight of hull as an example, we easily arrive at the weights of hulls having equality of strength and built upon the proportions under examination.

Let the above numbers stand for dimensions; the length of a vessel having equal capacity but a different ratio of length to breadth will be found by the following formula—

$$L = \sqrt[3]{6{\cdot}33\, R^2}, \qquad (4.)$$

The *extent* of the skin, and all the other longitudinal strengthening will, of course, vary directly with the surface; and its *thickness* to maintain equality of strength, directly with the ratio of the length and depth.

Continuing to employ the foregoing numbers for dimensions, we find the content of the figure to be 1·9, and its surface 14·0277. The following table exhibits clearly the comparative surfaces and weights of the various classes, and the resulting per centum of displacement required by each class for longitudinal strength.

a. Class.	b. Ratios of L to B.	c. L.	d. B.	e. D.	f. Surface.	g. Comparative Surface.	h. Comparative L. to D.	k. Comparative weights of Long. Iron.	m. Per ct. of Displacement of Long. Iron.
Example	6·333	6·333	1·000	0·600	14·0277	1·00000	1·00000	1·00000	18·40
A	3·37	4·159	1·234	0·740	11·5550	0·82373	0·53240	0·43860	8·05
B	4·03	4·678	1·164	0·698	12·1746	0·86790	0·63470	0·55085	10·14
C	5·00	5.410	1·082	0·649	12·9948	0·92637	0·78947	0·73134	13·46
D	5·84	6.000	1·027	0·617	13·6737	0·97476	0·92210	0·89883	16·54
E	6·86	6·680	·974	0·584	14·3908	1·02588	1·08470	1·11277	20·47

In the above table the quantities in columns *c*, *d* and *e* are such that, while they maintain equal capacity with the example, each preserves its own peculiar ratio of length to breadth. The quantities in column *f* give the corresponding extent of surface of the figure shown in the cut; those in column *k* are obtained by multiplying corresponding quantities in columns *g* and *h*, column *h* representing the comparative thickness of the longitudinal iron necessary to maintain equality of strength in hollow beams having the proportions given in the table.

The transverse stiffening would be practically uniform for the different classes, and is, as we have seen, 3 per centum of the displacement in the example.

The *equipments*, which, in this case, would include all wooden decks, all joiner work, masts, rigging, sails, boats, anchors, &c., &c., may be taken uniformly at 15 per centum of the displacement.

The total weights of vessel, exclusive of machinery, coals and cargo would therefore be as follows:

Class A	26·05	per	centum	of the	displacement.
" B	28·14	"	"	"	"
" C	31·46	"	"	"	"
" D	34.54	"	"	"	"
" E	38·47	"	"	"	"

With the foregoing, in connection with the co-efficients of performance achieved by each class, we may arrive at the actual displacements, powers and weights of steam machinery and weights of coals necessary in each case to carry 3,000 tons of cargo a distance of 3,000 miles in 10 days. Whence the first cost of the ships and machinery may be estimated.

This is shown in the following table, where the horses-power of the machinery is determined by the co-efficient of performance belonging to each case. The weight of the machinery is taken at one ton for every 10 horses power, and the coals at one ton per day for every 30 horses power. The displacements given supposes half the coals burned out. The cost of the hull and equipments is taken at $250 per ton weight. That of the steam machinery at $40 per indicated horse-power. These latter quantities are, of course, variable with time and locality as well as with the character of the detail design, but they are sufficiently near the average for purposes of correct comparison.

Class.	Co efficient of Performance.	Weight of Cargo.	Weight of Hull and Equipments.	W'ht of Steam Machinery.	Wh't of Coals.	Mean Displacement.	Horses Power.	Cost of Hull and Equipments.	Cost of Steam Machinery.	Total Cost.
		Tons.	Tons.	Tons.	Tons.	Tons.		$	$	$
A	134·9	3,000	1,490	463	1,544	5,725	4,633	372,500	185,320	557,820
B	155·1	3,000	1,592	400	1,332	5,658	3,998	398,000	159,920	557,920
C	175·7	3,000	1,815	358	1,192	5,769	3,576	453,750	143,040	596,790
D	177·8	3,000	2,097	366	1,218	6,072	3,655	524,250	146,200	670,450
E	198·9	3,000	2,430	336	1,120	6,331	3,360	607,500	134,400	741,900

The annual expense of the capital invested in ships is as follows:

Wear and tear	10	per cent.
Depreciation	5	"
Insurance	10	"
Interest	7	"
Total	32	"

The current running expenses will be equal for the different classes under consideration, with the exception of the coals, the variation in which is shown in the above table. In the following table it is assumed that each vessel will make eight round trips per annum, and that the cost of the coal in the bunkers is $6 per ton. Adding these two variable quantities together, we have the comparative annual expense of running steamers of equal gross earnearning capacity.

Class.	A.	B.	C.	D.	E.
	$	$	$	$	$
Annual expense of capital	178,502	178,534	190,973	214,544	237,408
Annual expense of coal	148,224	127,872	114,432	116,928	107,520
Total of the variable expenses	326,726	306,406	305,405	331,472	344,928

To complete the illustration, let us suppose that the gross earnings are $360,000 per annum in excess of the uniform annual expenses which have not been taken into account in the foregoing. The *net* earnings will then be as follows:

Class A	$53,274
" B	53,504
" C	51,765
" D	28,528
" E	15,072

And the per cents which these sums bear to the first cost of the ships in the respective classes are as follows:

Class A	5·96
" B	5·61
" C	9·15
" D	4·26
" E	2·03

From this it appears that, with the average performance of the entire British screw-steam navy, previous to 1865, for a standard, the proportion of four lengths to one breadth will earn better dividends upon the capital invested than any higher ratio. The excess over that of 5 to 1 is 0·46 per cent., in other words they may be said to be equal. The excess over 5·84 or say 6 to 1 is 5·35 per cent, and over that of 6·86 or say 7 to 1, it is 7·58 per centum.

As it may be fairly assumed that the vessels exhibiting the poorest performance have an inferior application of steam power, or are of inferior model, independent of the proportion of length to breadth, I have obtained the means of half the vessels in each class which exhibit the best performance. Those marked with an asterisk in list are the ones chosen. The results are given in the following table.

Class	Number of Vessels.	Ratios of Length to Breadth.	Speed in Knots per hour.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.} =$
A	6	3·38 to 1	10·340	159·2
B	32	4·15 to 1	10·671	181·1
C	39	4·71 to 1	10 016	197·9
D	34	5·71 to 1	10·170	198·1
E	13	6·98 to 1	11·217	252·4

(To be continued.)

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 237.)

THERE is no subject more interesting to the engineer than the early history of machines and structures with which he comes in contact. To trace the gradual developement of art, appreciating the anxiety, risk, and labor that has been expended upon it, possesses a fascination that might almost be defined as morbid curiosity. A judgment, however, which may be very harsh, when we consider the time and money that is expended in the search after antiquities without the hope of a result that will contribute anything to the general good.

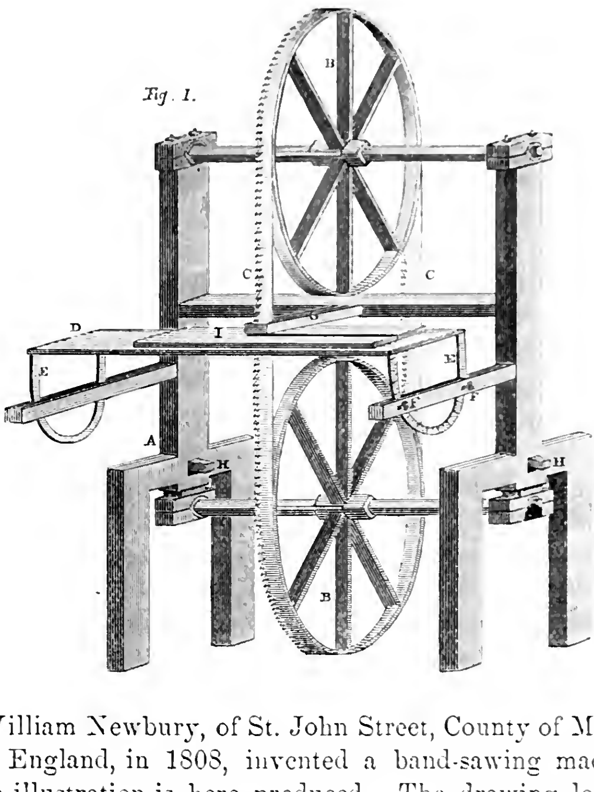
Contrasted with searches after the remains of the "mound builders," or the "north-west passage," we assume that the early history and facts connected with the mechanic arts forms a much more useful, and, to the mechanic at least, a more interesting field. The want of connection between operative mechanics and literature has, however, left but a meagre history of the useful arts compared to what we know of war, political contention and human passions generally.

We should venerate our patent system and cherish it, if for nothing else, then for what it hands down in the way of history of mechanic arts. Without these records we would be barren indeed as to the origin and progress of what is most vital and important to civilization, and it is with astonishment that we see a member of the British Parliament attack the patent system as useless and mischievous. We hope, as the greatest good that the honorable member may ever accomplish, that he will be able in his life to confer on his constituents a tithe of the good that has arisen from the laws he so violently assails. In the United States it is to be regretted that we are practicably cut-off from such records as exist of machines for working wood and iron. We have the British patents to be sure in our own language and on public file in various parts of the country, and no doubt they contain the most that is important or interesting in reference to the early history of machines. Yet, it is to be inferred that in wood-cutting machines and engineering tools, the continent can claim the greatest antiquity. Germany,

France and Spain have each contributed no doubt their share, and in advance of the English, but they lacked both the public spirit and that peculiarity which has been called abstraction in the Anglo Saxon people; a tendency to abstract utility, and deduce profit and advantage from what would be viewed only as curious or beautiful by others.

The band saw was alluded to in a former article of this series as an invention whose history seemed wrapped in obscurity. We now (although somewhat out of place) desire to qualify that statement and give the result of a more diligent search, which has been rewarded with the discovery of what must for the present be accepted as the first practical band-sawing machine, an instrument that contained about all the parts and was capable of all the functions found in the modern machine.

Fig. 1.



Mr. William Newbury, of St. John Street, County of Middlesex, London, England, in 1808, invented a band-sawing machine, of which an illustration is here produced. The drawing looks antiquated as to the plans of construction, but when we consider the

time and surrounding conditions of the art it is a surprisingly perfect machine. Letters patent from the crown were granted to William Newbury, Gentleman, for an invention of certain machinery for the purpose of sawing wood, splitting or paring skins and various other useful purposes, dated Jan. 30th, 1808.

We have in this machine the pivotal table with the axis of motion when the blade intersects the plane of the top, there is also shown feeding rollers at Fig. 2, similar to those afterwards patented to Woodworth for planing machines. There is also a graduated radius attachment shown at Fig. 3 for sawing true sweeps, in fact, aside from the trouble of placing and removing the saw the machine is quite as good as some machines that have appeared in the last five years.

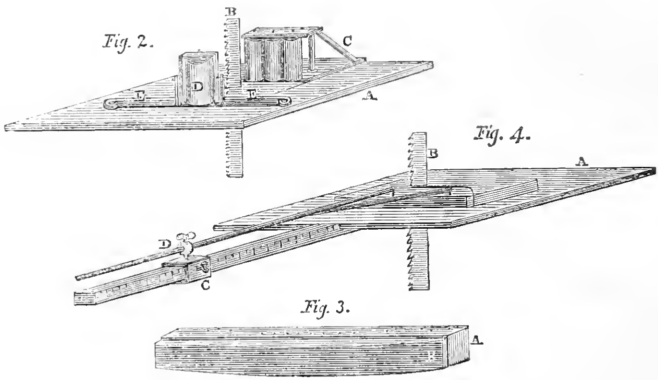


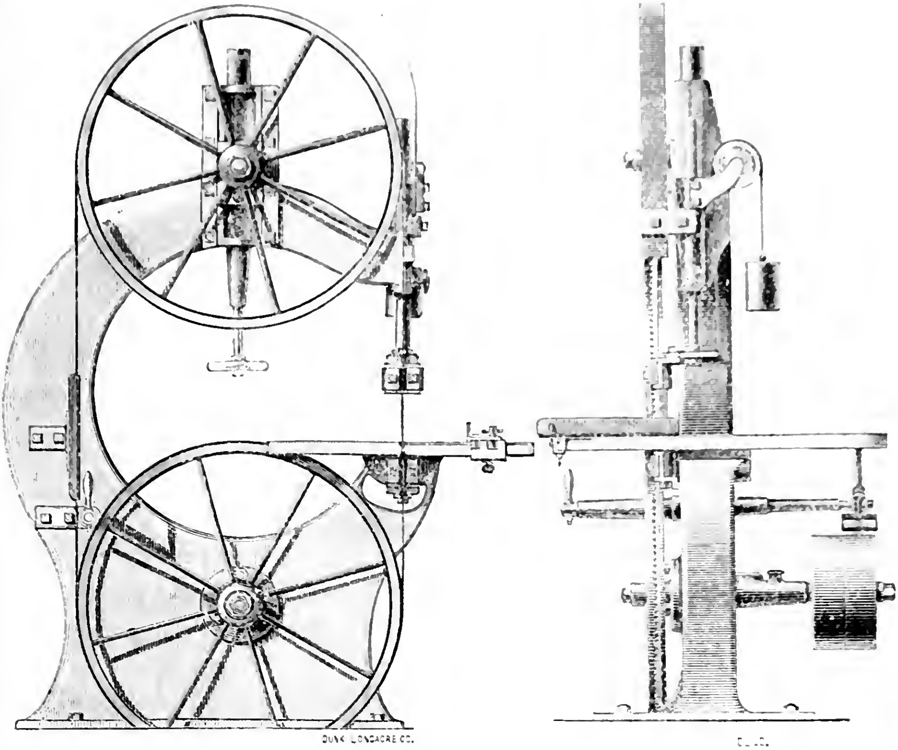
Fig. 2. *Fig. 4.* *Fig. 3.*

This machine is alluded to in "Holtzapffel's Mechanical Manipulation" as a very curious one, which is a sufficient warrant as to its non-use at that time (1846).

As the subject of band saws has been to this extent resumed, we avail ourselves of the opportunity of presenting an illustration of an improved band saw from the designs of Richards, Kelly & Co., of this city, Figs. 5 & 6. The general style of framing and guides is the same as their machines illustrated in former articles. The frame is, however, of rectangular curved section, without ribs and perfectly plain on its exterior. The main new feature, aside from the minor changes in mechanism, is the wheels, which are of *wrought iron* covered with wood, and then with a layer of heavy harness leather. This form of wheel combines great strength with elasticity and a neat appearance. The elasticity in the wheel acts directly upon the

blade without the intervention of other mechanism and lessen the danger of breaking. The wood is fastened to the iron rim by screws and the leather is glued to the wood so that the joints are all reliable. The wheels of the machine illustrated are of 40 inches diameter, the iron rim $\frac{1}{4} \times 2$ inches, the wood $\frac{7}{8} \times 2\frac{1}{4}$ inches, the spokes 8 in number of round iron $\frac{5}{8}$ inch diameter.

Figs. 5 and 6.

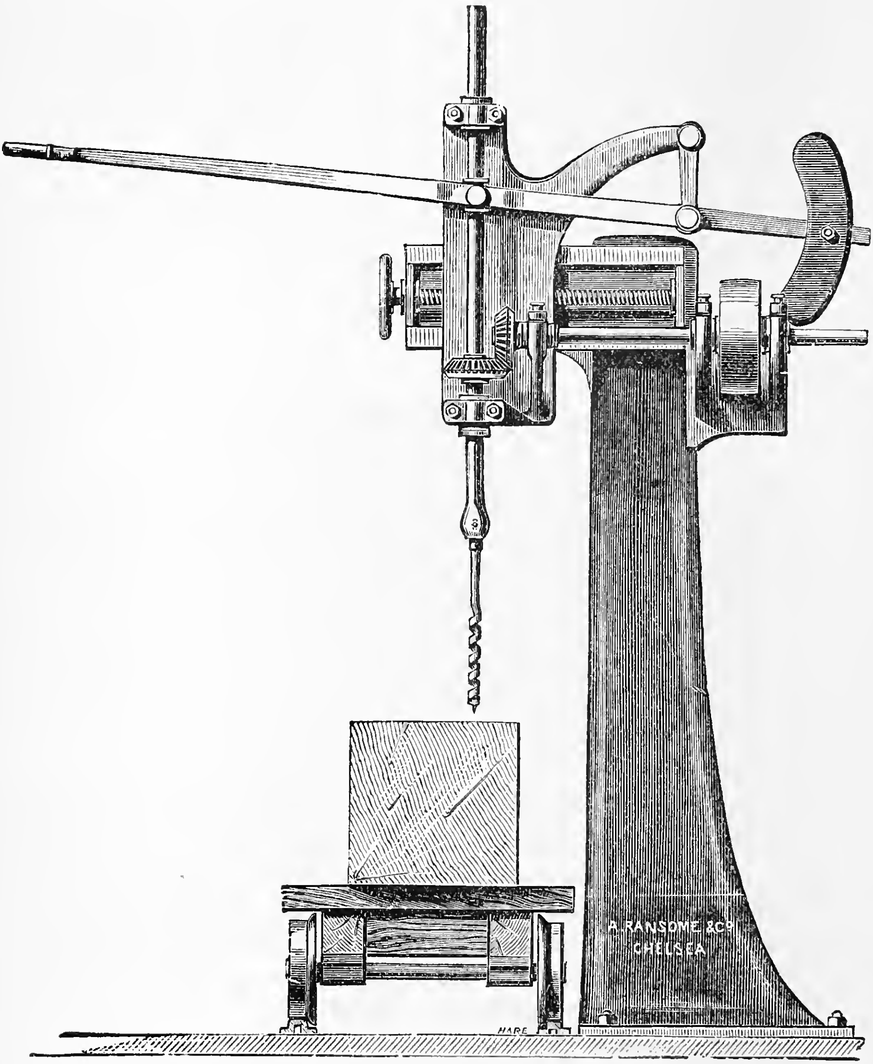


The wrought iron wheel will be adopted hereafter by this firm on their larger machines and can be built of any diameter required up to 12 feet.

We present at Fig. 7 an illustration showing a side elevation of a boring machine by Allen Ransome & Co., of London, England. The machine is intended for boring in wood framing of all kinds, The spindle has a lateral traverse of 15 inches, and a vertical movement of 16 inches.

The weight is, with the carriage, about two tons.

Boring machines for wood correspond to drilling machines for metal, except as to the greater speed of the spindles, the adjustments and movements are the same. The modifications met with are as



various as the purposes to which they are applied and no standard form of construction has been adopted by the makers.

We will notice, however, a machine built in Indiana some four

or five years since wherein the traverse movement of the spindle was performed by power; that is, the lateral adjustment was performed by the machine itself through the means of friction clutches. This involved quite a complication of mechanism beneath the spindle without any equal object in adjusting the bit; an operation that requires but little power and has in the end to be governed by hand adjustment; in short, it is as easy to adjust the bit and spindle as it is to adjust the friction clutches. A compound vertical machine with two spindles having 12 inches traverse and 16 inches vertical movement of the spindles, was arranged, and is now building by Richards, Kelly & Co. for J. Dripps, C. E., Superintendent of Motive Power, Pennsylvania R. R. Co. This machine is framed in iron, weighing 1500 lbs. with traversing table.

(To be continued.)

ENGINEERS AND MACHINISTS.

By J. Richards, M. E.

The manufacture of machinery can, and perhaps should, be divided into three branches: engineering, machine fitting, and the commercial department. In this country a person or a firm, in order to found a successful business, must, in some degree, compass all of these things; they must generate designs, carry them out in the construction of the machines, and then negotiate their sale. To theorize on the subject without considering the history of the mechanic arts, there would seem to be a legitimate division of these separate branches, and no doubt such a conclusion would be correct if it were practicable to divide them with the present degree of knowledge possessed of the forms of construction and means of fitting. And it is safe to assume that the necessity of this combination is found in the imperfections of the art. Designs have to be qualified by experiment, and sales negotiated that are contingent upon successful performance, and in order to meet these conditions the whole must co-operate together.

That the principle is the same in a general way that leads to a division of labor in the shops, cannot be denied, the object being to systematize and produce cheaper. Any manufacturer that is not trammeled and worried by the care and risk of making designs and plans, and can give his entire attention to shop manipulation,

can make machines better and cheaper than if he attends to both. Again, relieve him of all commercial care and responsibility except the purchase of material and his pay roll, and the result must be that no mongrel business could be done to compete.

In England we have an indisputable evidence of this in the manufacture of staple articles, at Birmingham and elsewhere. The manufacturers go to London and contract for a season's production with some commercial house, to whom all their goods are sent. They then go home to give their attention solely to the details of their shops. The plans and designs have been fixed by custom and experience and the goods are sold by others. The consequence is that the cost of production has decreased until they can defy competition.

The great engineering firms of our own and other countries, it is true, have been founded and conducted on a different principle, and their example offers a strong argument for its continuance; but at the same time there are faults attending the most successful that must not be overlooked, one of which is that such shops are generally the product of a one-man power—some one endowed with an extraordinary ability and a versatility of talent that enables them to plan, build, and sell. This focal one-man power is to be found in nearly every successful engineering firm in existence, and the result is that when this power fails and is not supplanted by one similar and equal, there is soon a want for an epitaph. In fact, the ordinary ranks of mankind furnish but few men who can master and execute the details of a successful engineering business as now conducted.

There is against the system a powerful argument found in the fact that efficiency can only be attained by strict attention to one thing; and while we have a few first-class shops that do attain it in all departments, we have for each one such a score that make a miserable failure. Look over our country and no shop will be found however small, or no matter how much risk is being run in the use of a limited capital, but that is trying to produce something new and startling, some new modification of machines, or novel experiment that belongs to the engineer and not the machinist. It is even common for persons to advertise as engineers and machinists who have not the least capacity, education, nor means to generate designs nor to calculate plans; the result is generally failure—the inevitable failure to succeed in engineering, and the consequent fail-

ure of the machine shop for want of means squandered in experiment.

What is true in this respect with regard to engineering is equally true in reference to the commercial department of the machine business. As our shops are now organized, a machinist, to start business, must have all the adjuncts of a counting-room—a complication of accounts, a correspondence all over the country—he must advertise, travel—in short, expend on a business, no matter how small, the same amount that would be needed if he were doing ten times the business. This is the result of our conglomerate system of machine manufacture. And while it must be accepted as a necessity growing out of the unfortunate state of the art, it can do no harm to understand it and talk about. And while circumstance must perforce for a time maintain this state of affairs, our highest good and greatest success must ultimately grow out of a different system, in which the engineer is responsible for designs, the machinist for his work, and the commercial man for the contracts.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 271.)

A Large Leather Belt.

"At the New Jersey Zinc Co.'s works at Newark, N. J., is a quadruple leather belt of unusually large dimensions. It is 102 feet long, 4 feet wide and weighs 2200 lbs. The outside layer consists of two widths, the second and fourth layers of three widths, and the third layer of four widths; all the layers being rivetted and glued together, and the end joints of the pieces forming the several layers are lapped to give the greatest tensional strength to the whole.

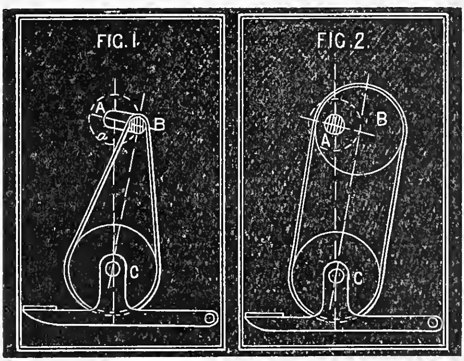
"It runs on an engine band wheel 24 feet diameter, with straight face 4 feet wide of smooth turned iron and over a driven pulley on the line shaft of 7 feet diameter having similar face, the centre of which lies 5 feet above the engine shaft.

"It has been in use three years, is doing well and giving no trouble, even when doing its heaviest work.

"The engine has a cylinder of 28 inches diameter and 5 feet stroke, makes 35 revolutions per minute under 70 lbs. of steam and 14 lbs. of vacuum; estimated capacity of belt 250 horse-power, velocity 3080·7 feet per minute, and 49·3 square feet of belt traveling per minute per horse-power."—*J. Hartman.*

"*Band Links.*—Where tension alone, and not thrust, is to act along a link, it may be flexible, and may consist either of a single band or of an endless band passing round a pair of pulleys which turn round axes traversing and moving with the connected points. For example, in Fig. 1, A is the axis of a rotating shaft. B that of a crank pin. C, the other connected point, and B C the line of connection; and the connection is effected by means of an endless band passing around a pulley which is centered upon C, and round the crank-pin itself which acts as another pulley. The pulleys are of course secondary pieces, and the motion of each of them belongs to the subject of aggregate combinations, being compounded of the motion which they have along with the line of connection, B C, and of their respective rotations relatively to that line as their line of centers; but the motion of the points B and C is the same as if B C were a rigid link, provided that forces act which keep the band always in a state of tension.

"This combination is used in order to lessen the friction, as compared with that which takes place between a rigid link and a pair of pins; and the band employed is often of leather, because of its flexibility."—*Rankine's Mill Work*, p. 213.



"In Fig. 2 we give a substitute for Fig. 1, in which an excentric B takes the place of the crank, allowing a straight shaft to be used. When the excentricity of B equals the radius of the crank, the result is the same, but experiment has proven, in the case of the excentric used in the treadle arrangement of the latter, that the motion lacks freedom, the treadle moving heavily."

"*Cement.*—A cement for joining pieces of leather, one which repeated tests have shown to be very efficient, may be made by dis-

solving in a mixture of ten parts of bi sulphide of carbon and one part of oil of turpentine, enough gutta-percha to thicken the composition. The leather must be freed from grease by placing on it a cloth and pressing the latter with a hot iron. It is important that the pieces cemented be pressed together until the cement is dry."

"*Cement for Fastening Leather to Iron or Glass.*—To one quart of glue, after it is dissolved in good cider vinegar, add one ounce of Venice turpentine, let it cook about half a day, when it is fit for use."—O. L. C., of N. H., in *Scientific American*, Feb. 11, 1871.

"*Cement for Leather Belting.*—"Of common glue and American isinglass, take equal parts; put them in a boiler and add water sufficient to just cover the whole. Let them soak ten hours, then bring the mixture to a boiling heat and add pure tannin until the whole becomes ropey or appears like the white of eggs. Apply it warm. Buff the grain off the leather where it is to be cemented; rub the joint surfaces solidly together, let it dry a few hours and it is ready for use. If properly put together it will not need riveting, as the cement is nearly of the same nature as the leather itself."—J. S. of Minn., in *Sci. American*, Feb., 1871.

Cement for fastening Chamois and other Leather to Iron and Steel.—Dr. Carl W. Heinischen, of Dresden, gives the following: "Spread over the metal a thin, hot solution of good glue; soak the leather in a warm solution of gall-nuts before placing on the metal, and leave to dry under an even pressure. If fastened in this manner it is impossible to separate the leather from the metal without tearing it."—G. E. M., of Texas, in *Sci. American*, Feb., 1871.

"*Adhesive for Rubber Belts.*—Coat the driving side with boiled linseed oil or cold tallow, which may be done while the belt is running and then sprinkle the surface evenly over with fine chalk. This will not injure the rubber, as the belt does not absorb the tallow."—C. E. G., of Ct., in *Sci. American*, Dec., 1870,

A good adhesive for leather belts is printer's ink. I have the case of a six inch belt running dry and smooth and slipping, which latter was entirely prevented for a year by one application of the above.

(To be continued.)

IRON MANUFACTURES IN GREAT BRITAIN.

THIRD PAPER.

By R. H. Thurston,

First Asst. Eng., A. A. Prof. Nat. Philos., U. S. N. A.; Member of the Institute.

(Continued from page 259.)

The next most interesting district to the American engineer is that from which we receive the large quantities of Scotch iron that are imported into our market.

Scotch practice is in marked contrast with that just described.

The furnaces are smaller than those of Yorkshire, seldom rising above 60 feet in height, as the materials charged do not seem able to bear great crushing weights. Even at 60 feet, trouble is found to arise from the coke falling down into the hearth unconsumed.

The number of furnaces reported in blast, at the time of our investigation, was 127, with a production of about one and a quarter millions of tons annually.

The production of the larger furnaces even seldom exceeds 200 tons per week.

As raw coal is used for fuel, the furnace gases consist largely of hydro-carbons, and are allowed to pass off freely from the open tops of the furnaces. No means of utilizing them are usually adopted, as attempts to take off the gases have generally occasioned serious irregularity in the action of the furnaces.

Table 1 contains an analysis of the remarkable "Scotch blackband," which is the principal ore of this district. It contains, usually, over 60 per cent. of metallic iron after calcining.

The roasting is often effected without expense for fuel, the carbon contained in the ore being sufficient for the purpose, and, in exceptional cases, amounting to 25 per cent. of its weight; the per centage usually ranges from 4 to 10. The calcined ore is charged into the furnace with from 20 to 30 per cent. of limestone, making about two tons, and sometimes less, of these materials per ton of iron made. The proportion of fuel used is, however, extravagant, averaging probably between 45 and 50 hundred weight per ton of iron, and to this is to be added the amount of "slack" required for heating the blast and making steam.

The countrymen of Neilson either do not appreciate the full value of his invention, or else are unable to avail themselves of it, and it seems quite surprising to find here a temperature of blast rarely exceeding 700°. Its pressure is, upon the average furnace, 3 pounds per square inch. The heating stoves are usually fitted with the "pistol pipe." The furnaces are usually in close proximity to both ore and coal, which are frequently drawn from the same shaft. The consequent cheapness of materials may have some influence in producing the great difference between the Scotch and the Cleveland practice.

A change for the better is said to be now noticeable, and it will, undoubtedly, be hastened by the increasing expense of Scotch ores and fuel and the rising competition of other districts.

The product of Scotch furnaces is usually of the well known dark foundry grades, and the phosphorous which it contains probably gives it its fluidity and easy fusibility. The lighter grades are made into fair wrought iron by careful puddling, and furnish a large proportion of the iron worked by the great shipbuilding establishments of the Clyde.

Staffordshire is at present the largest iron making district of Great Britain, but there is little to be noted here, the methods adopted being neither as economical as in Cleveland nor as wasteful as in Scotland, and similar remarks will apply to the iron producing portion of Wales. The latter district has the best coals for metallurgical purposes to be found in the country, and the manufacture is very largely developed both of pig metal and refined. There are about 120 furnaces in blast in South Wales, and large quantities of cast iron are worked into nails, bars and plates, and a considerable amount of steel is made by the Bessemer process. We give analyses in Table 1 of Staffordshire and Welsh ores.

The immense and extremely rapid growth of the manufacture of steel by the pneumatic process, in England, has caused a correspondingly urgent-demand for ores of exceptional purity. It is well known by every engineer that this process cannot be successfully worked where the pig metal is not rich in carbon and free from sulphur and phosphorus. A minute quantity of sulphur may be present in the pig metal, as manganese acts, to a certain extent, as its antidote, but the presence of a fraction of one per cent. of phosphorus is fatal. As English ores are almost invariably contaminated to a considerable extent with these elements, the mines and

furnaces of Cumberland—almost the only locality where an ore can be obtained of a quality that may be used in this process—are rapidly increasing their production, while prices are rising so steadily and rapidly as already to cause some uneasiness to be felt by consumers.

The Cumberland and Lancashire, or "West Coast district," is situated at the north-west corner of England, and the largest manufacturing town is Barrow, a few years ago a mere hamlet, but now a city of 25,000 people. We give an analysis of the ore in Table 1. It is a rich, pure, red hematite, containing barely a trace of either sulphur or phosphorus, and is found in irregular masses in the limestone; its principal impurity is silica.

The fuel is generally Durham coke, with some admixture of native, which, however, contains too much sulphur and phosphorus. The furnaces are of medium size, with blast heated to 800° Fahr., and at a pressure of about 4 pounds per square inch.

The product is about 400 tons per week as an average for the more recent furnaces.

The manufacturers of Cumberland are now receiving above £4 per ton for their No. 1 pig metal—over fifty per cent. more than is paid for other irons—and are still unable to supply the market.

British manufacturers still use the old crucible process in making the finer grades of steel, and the amount produced is by no means small in the aggregate, but, for the "mild steel" which is required for rails, boiler and ship plates, shafts, and many other purposes for which wrought iron was formerly used, the pneumatic process is principally employed.

The largest manufacturing establishment working this process is the Barrow Iron and Steel Works.

Here the pig iron is melted in eight-ton charges in *cupola* furnaces, with coke as fuel, the pressure of blast being about one pound per square inch. For reheating the ingots, the Siemens gas furnace is used, and is found vastly more efficient, in every way, than the ordinary furnace. Uniformity of character in the pig iron is secured by breaking the pigs and distributing the pieces among the large number of heaps into which the stock is separated.

The spiegeleisen is principally imported from Germany, and the war, just terminated, has seriously interfered with steel making throughout Great Britain, although, occasionally, as at the Dowlais Works in South Wales, unusual foresight had, at its outbreak, secured a large stock—sufficient for several months.

Some difficulty is found in making, with ordinary spiegeleisen, a steel rich in manganese and at the same time containing a sufficiently small per centage of carbon, and some attempts have been made to manufacture an alloy of iron and manganese, with a small quantity of carbon, for the especial purpose of making a good quality of metal containing less than one-half per cent. of carbon. Such a metal would be largely used where sudden strains are to be resisted, as in armor plate and ordnance. The manufacture of this "ferro-manganese" has not, however, become a commercial success, although good samples have been made.

The greater portion of steel made by the pneumatic process in England is, as in the United States, rolled into rails. Barrow rails are well known in this country, thousands of tons having been imported for our principal railroads.

The Dowlais Works are also large manufacturers of Bessemer steel. This immense establishment was built up by the well directed intelligence of one man, Sir John Guest. About 10,000 people are now employed in its works and mines.

The Dowlais Works produce annually 30,000 tons of steel rails, from ore mixtures consisting largely of Cumberland hematite, and probably four times as great a quantity of iron rails from native ores. A considerable quantity of Spanish-Bilboa ore is imported, at a cost of about 16 or 18 shillings per ton, and being of quite good quality, it mixes well with more expensive ores, in steel making, and with native ores for iron making.

We noticed at Dowlais, as well as at other rail mills, that the rolls were arranged to reverse, the older by clutches, the more recent by the Ramsbottom reversing engine, which seemed always to give perfect satisfaction to both workmen and managers.

We found Bessemer plant and steel rolling mills at the well known Sheffield establishments of John Brown & Co. and Cammell & Co., both of which firms have a reputation in the United States as makers of steel rails. These establishments have immense rolls for the manufacture of armor plate, which they turn out of a thickness of 14 and 15 inches. The rolls are only remarkable, however, for their great size and strength; there is no novelty in their design.

The "Siemens-Martin" process of steel making is in successful operation in Great Britain, as in the United States, and we had the

pleasure of witnessing it at the "Siemens' Works," at Landore, South Wales.

The Bessemer process is only adapted to working, advantageously, the purest of cast iron, and that only when containing a large amount of graphitic carbon and of silicon; the character of the charge cannot be well ascertained until actually poured from the converter into the ingot mould, when it is too late to remedy any defect; scrap metal and white irons cannot be used in decarbonizing. The great advantage of the process is simply the rapidity of conversion and its economy when competing with the old method of steel making.

In the Siemens-Martin process the pig metal is melted on the hearth, and, under the intense heat of the Siemens gas furnace, it is kept fluid, even after the addition of wrought iron—either in form of scrap or puddle balls, usually—has decarbonized it.* Spiegeleisen is then added, as in the Bessemer process, and the metal is tested by withdrawing a spoonful, and more pig iron or scrap or spiegeleisen, as either may be required, is added until the desired quality is obtained.

In this process a white cast iron may be used to better advantage than grey, scrap metal and other cheap decarbonizing material may be used, and the charge need not be tapped off until it is of precisely the quality demanded, as the molten metal may lie as long as may be convenient under the neutral gas flame without loss of iron or change of character.

The process was in regular working at Landore, and the product was of excellent quality and admirable in its uniformity of character.

The commercial success of the process will depend largely upon the relative cost of foundry and forge irons and upon the price of scrap, but from statements of cost furnished at Landore, it would seem a much more profitable process of steel making, at present, than the pneumatic method. The metal being worked on the hearth of the reverberatory furnace, a judicious use of good fettling material, by taking off sulphur and phosphorus, enables a less pure iron to be worked, also, than can be used in making Bessemer pig.

* The inventors and those who are working this process have a theory that the decarbonization is, at least partly, due to a "dissociation" of the carbon from the metal at the intensely high temperature at which it is kept in the "Siemens furnace, and the remarkably small proportion of malleable iron required seemed to indicate that the process is not one of *dilution* alone.

At Landore some excellent specimens of steel were shown also, which were made by the Siemens "ore process," at even less cost than the Siemens Martin steel. This process will soon be patented in this country, and, for many localities, will probably be found the most valuable process yet introduced. The method had been regularly in use for several months at Landore, and very successfully, and the four new furnaces, now constructed especially for the ore process, are expected to give yet more favorable results. We are not yet at liberty to describe the details of the process.

One cause, undoubtedly, of the success of British Bessemer steel makers is the invariable employment of a professional chemist at the works, who analyzes carefully all stock received, and all grades of product. Frequently he makes a set of analyses of metal at various stages of manufacture, and thus keeps a useful check upon all employees, from purchasing agents to the workmen in the rolling mill.

A chemical test determines the value of all materials before purchase, and equally well whether a cracked rail is faulty in the character of the metal or from carelessness at the rolls, and as work is usually paid for "by the piece," the loss does not usually fall upon the employers if caused by ignorance or carelessness of employees.

The use of steel seems to be extending more rapidly in Great Britain than in the United States: crankshafts and other parts of the steam engine, screw propellers, and, to some extent, steam boiler and ship plates are made in steel. It is but a short time since manufacturers were unable to guarantee steel plate of greater thickness than $\frac{1}{4}$-inch, but good plate can be obtained now of any thickness that can ordinarily be used in either boiler making or shipbuilding, and a steel containing from 0·3 to 0·5 per cent. carbon is probably before many years destined to supersede wrought iron almost entirely. Such a steel has all of the ductility and malleability of wrought iron, combined with very much higher absolute tenacity and resilience. Its introduction renders many constructions practicable that were quite impracticable with wrought iron, and the coming "steel age" may present as great a contrast with the expiring "iron age" as is seen between the latter and the "age of bronze."

Analysis of British Ores and Irons.

ORES.

LOCALITY.	CLEVELAND ORE.		STAFFORDSHIRE.		S. WALES.	CUMBERLAND.
			S.	N.		
Protoxide Iron	39·92	43·02	30·96	46·53	40 30	......
Sesquioxide Iron	3·60	2·86	......	......	......	95·16
Protoxide Manganese	0·95	0·40	0·73	2·54	1·03	0·24
Alumina	7·86	5·87	0·13	0·97	1·43	......
Lime	7·44	5·14	1·84	2·41	1·44	0·07
Magnesia	3·82	5·21	2·90	1·39	2·77	......
Potash	6·27	......	......	......	......	......
Silica	7·12	7·12	0·15	......	......	......
Carbonic Acid	22·85	25·50	22·13	30·77	28·33	......
Phosphoric Acid	1·86	1·81	0·26	0·69	0 88	trace.
Sulphuric Acid	trace.	......	trace.	0·04	trace.	trace.
Bisulphide Iron	0·11	......	0·12	0·34	0·09	trace.
Water	2·97	3·48	2·39	1·47	0·74	......
Organic Matter	trace.	0·15	0·10	10·46	0·29	......
Ignited Insol. Residue	1·64	0·05	37·90	2·27	22·48	5·68
	100·41	100·61	99·61	99·88	99·68	101·15
Metallic Iron	33·62	35·46	24·88	36 39	31·63	66·60
Authority	A. B. Dick.	A. B. Dick.	J. Spiller.	A. B Dick.	A. B. Dick.	A. B. Dick.

IRONS.

LOCALITY.	CLEVELAND.		STAFFORDSHIRE.		S. WALES.	CUMBERLAND.
			S.	N.		
Carbon (graphites)	3·04	3·35	3·12	2·54	2 95	3·22
Silicon	2·73	1·57	1·16	2·71	1·96	3·02
Sulphur	0 04	0·04	0·05	0·04	0·28	None.
Phosphorus	1·30	1·38	0·44	1·07	0 63	0·06
Manganese	0·38	0·07	0·94	0·98	0·23	0·11
Nickel } Cobalt }	......	......	......	......	0 04	.....
Authority	Percy.	Percy.	Percy.	Percy.	E. S. Riley.	Abel.

Mechanics, Physics, and Chemistry.

ON CHLORAL HYDRATE.

By Robt. F. Fairthorne.

Amongst the most desirable additions to the list of medicines employed for the relief of the frail or diseased portion of the human family, a substance giving repose to the excited brain and body, procuring calm, refreshing sleep, and followed by no baneful effect to those using it, would be considered of the greatest value.

It has been said, "Blest is the man who first invented sleep." I do not suppose that he who finds the means for obtaining the same at pleasure is any less deserving of benediction.

In vain we look over the Materia Medica of our Pharmacopœia for a somnific that is both reliable and free from dangerous effect. We find opium, belladonna, aconite, morphia, fish-berries, chloroform, ether, digitallis, and stramonium; all reliable narcotics: but none of which can be taken without danger, and none without being followed by some evil influence.

Then, again, we find lactucarium, (lettuce opium,) hemlock, lupulin, hyosciamus, and valerian, (although occasionally efficacious and without deleterious properties,) are so unreliable that they are principally employed in cases of but slight indisposition.

Should we find, then, something combining in its character the reliability of the substances named in the first list, together with the immunity from evil characterizing those last mentioned, we would regard it with the greatest interest.

It would be premature, perhaps, to claim chloral as a perfect hypnotic, as it is scarcely two years since it began to be employed as a medicine.

It was discovered by Liebig, about thirty years ago, but remained as a scientific curiosity on the shelves of the laboratories of Europe until Dr. Liebreich, of Berlin, made known its value as an anæsthetic to the medical profession.

He was led to experiment with it, knowing that upon addition to an alkaline solution, the constituents of chloral are separated into chloroform and formiate of potash. The blood being slightly alkaline, containing as it does small quantities of the carbonates of

soda and potassa, suggested to his mind the probability of this reaction taking place in the human subject.

It is found, however, that hydrate of chloral differs in its effect from that of chloroform in not producing complete anæsthesia, except during a very short period (a minute or two) after having been administered, and this only when very large doses have been taken. This can be accounted for by the fact that the blood contains so minute a portion of the alkaline salts that when chloral is decomposed by it chloroform must be very slowly developed.

That this production of chloroform really takes place, I think there can be no doubt, as has been conclusively demonstrated by the experiments of Dr. B. W. Richardson, (F. R. S.,) before a meeting of the British Association at Exeter, England. He produced that article upon mixing the hydrate with freshly drawn blood and distilling the same. Previous to distillation chloroform was perceptible, so that it must be generated immediately on contact with the blood. (See *Medical Times and Gazette*, Sept. 4, 1869.)

Dr. Demarquay of the French Academy, however, does not agree with this theory, thinking that the hydrate of chloral penetrates the system unchanged, but the weight of testimony of those employing it is in favor of Liebreich's idea. I would suggest, however, the possibility of but a small portion of the chloral being split up, so as to produce only a minute portion of chloroform, and the remainder entering the body unaltered.

It is noticed that after full doses of this substance have been taken, there is a short space of time during which complete anæsthesia takes place, and, although sleep is prolonged several hours, yet entire insensibility is confined to but a few minutes. This may be due to that period during which chloroform is first produced, being that moment when probably the largest amount is formed.

The hydrate of chloral given in moderate doses (from 10 to 35 grains) usually procures sleep of seven or eight hours' duration, which in appearance is natural, and in effect refreshing. Neither the frequency of the pulse nor of respiration are usually altered by it. No disagreeable effects, except in very rare instances are perceived upon awakening, and even in these only slight headache and nausea follow, and which soon pass off. Even in quite large doses, (from 50 to 80 grains,) it seldom causes any unpleasant symptoms, upon the patient resuming consciousness.

Dr. Lincoln, of Boston, having a patient who had been without

sleep for a week, with the exception of an hour a night, and who had taken opium, valerian, lupulin, cannabis indica, and hyoscyamus in vain, gave 15 grains of hydrate of chloral nightly, with the procurement of seven hours' sleep in each nocturnal period.

It appears to be the most perfect hypnotic known, and the above is only a fair specimen of numberless instances where its administration has been followed by equally good results. With the exception of one or two cases, in which very large quantities were accidentally taken, no evil has been caused by it. "*The Lancet*," of Nov. 26, 1870, gives an account of a patient who took 160 grains of the hydrate of chloral without any unpleasant consequences. Dr. Jas. Rodman reports in the "*American Practitioner*," Oct., 1870, that 270 grains were taken without any other alarming symptom than that of 18 hours' sleep; and in another case the enormous quantity of 460 grains was taken by mistake by a female nurse at the Philadelphia Hospital, producing effects resembling those of an overdose of opium. She was supposed to have taken that drug, and was treated accordingly; by which treatment she completely recovered.

Dr. Penrose, of the University of Pennsylvania, had a patient who took 210 grains (in divided doses in the space of two hours,) which was followed by 7 hours' sleep, and no unpleasant symptom except headache and stupor, which lasted several hours after awakening. He also states that he has given another patient from 5 to 10 grains nightly for a year, and finds that the lady taking it is as susceptible to its sudorific influence now as when she began to use it, not requiring any increase of dose. No bad effect has been experienced in this case, except an occasional disposition to produce lachrymose secretion and slight obscurity of vision. This superabundant secretion has been noticed by others who have used it for some length of time.

An intelligent lady of my acquaintance informed me that, her husband having had occasion to take chloral, she noticed it caused a profound sleep of two hours duration. His respiration was sometimes very irregular, ceasing for so long a time as to be quite alarming. Occasionally I meet with persons who inform me that this medicine acts as a stimulant and excitant, tending to keep them wakeful.

So far as I am able to learn, only one death has been ascribed to the use of chloral. The account is given of this case in the "*Medical*

Times" for February 15, 1871. A woman suffering from great mental excitement, almost amounting to insanity, took 180 grains in doses of 30 grains each, at intervals of several hours, during the period of three days. She died two days after the last dose was taken. Dr. Jas. Tyson, and other physicians who have read this report, think that there is room for doubting the correctness of attributing the death of the patient to the effect of chloral.

According to Dr. Liebreich, one fact connected with its therapeutic action worthy of attention is, that it possesses the peculiar and valuable property of neutralizing the poisonous effects of strychnia. Another singular property it possesses is, that, like chloroform, it nauseates birds when given to them.

Doctors Richardson and Liebreich state that chloral acts first on the volitional centres of the cerebrum, next on the chord, and lastly on the heart.

Hydrate of chloral as found in commerce occurs in two conditions. One form is that of tabular pieces of various sizes, having a crystalline structure, which, when freshly fractured, presents considerable resemblance to spermaceti. Another form is that of loose acicular crystals, shining and transparent when recently prepared, but becoming more or less opaque by age, even when kept in tightly stoppered bottles. I think this change is probably due to the action of light, as the vapor of alcohol, if exposed to sunlight in the presence of chlorine explodes, accompanied by bright flashes of light. Chloroform is also partially decomposed by light, chlorine and hydrochloric acid being developed.

Chloral is formed by passing dry chlorine through alcohol until fumes of muriatic acid are no longer given off and the spirit has assumed a yellow color. This liquid is heated until it boils. It is then mixed with three times its bulk of sulphuric acid and distilled, and finally redistilled over quick-lime.

Its formation appears to depend upon the affinity that chlorine has for hydrogen, the former gas taking it from alcohol, and being disengaged during the process as hydrochloric acid. Alcohol composed of $C_4\ H_6\ O_2$ by abstraction of two equivalents of hydrogen, (which takes place at the beginning of the process,) becomes aldehyd $C_4\ H_4\ O_2$. As the chlorine continues to pass, it takes with it three more equivalents of hydrogen, leaving, however, three of chlorine in their place; the aldehyd, therefore, is decomposed, and $C_4\ Cl_3\ HO_2$ remains, which is chloral. This is a volatile, pungent

liquid, of nearly the same specific gravity as chloroform, being 1·500, that of chloroform 1·490. It has a strong affinity for water with which it combines, and with one equivalent of it, forming the hydrate just described. It also forms a crystalline compound by the addition of an equivalent of alcohol, which resembles the hydrate in appearance, but can be distinguished from it by being much less soluble in water.

Chloral, even when confined in hermetrically sealed tubes after being kept for some time, gradually changes into a solid porcelain like substance. When this is heated, however, it returns to the liquid state, and is of the same composition as previous to the change.

Pure hydrate of chloral, according to Dr. Rieckher does not take fire when heated in a spoon over a spirit lamp, but evaporates without residue. Solution of nitrate of silver should not be rendered turbid by it, thereby showing the absence of uncombined chlorine. Nitric acid, sp. gr. 1·20, either cold or hot should not produce any reaction with it. I find that it is readily soluble, when freshly prepared, in its own weight of water. After keeping and being occasionally exposed to the air it becomes less soluble, and sometimes its solution remains turbid for a few minutes after being made. With solution of subacetate of lead a dense precipitate is formed. The supernatant liquid becomes densely clouded upon further addition of the subacetate.

The hydrate is readily dissolved by alcohol, ether, oil of turpentine and benzole. It is also soluble in bi-sulphide of carbon and the fixed oils. The solution in the latter article might prove an important method in the hands of the physician for tapical application, perhaps available in neuralgia and gouty affections. I find that benzine also dissolves it slowly.

When hydrate of chloral is added to a strong solution of bi-chromate of potassa and heated after the addition of a few drops of nitric acid, the olive-green color peculiar to the alcoholic test is gradually developed. After standing, this becomes blue, and if liquid ammonia is afterwards added in large excess, it assumes a currant-red color. Chloroform treated in the same manner, produces a deep orange, retaining this color even after the ammonia has been added.

As an evidence of the growth in its popularity as a remedy, I will state that in January, 1870, the price of an ounce of chloral

was greater than that of a pound at present, and that the last named quantity is at present consumed by druggists in compounding physicians' prescriptions in the same space of time as was required to dispose of an ounce at that period.

There are other methods for preparing chloral than that referred to in this communication. I would merely say that chlorine acting upon substances capable of undergoing the alcoholic fermentation will produce it.

ON THE USE OF HYDRAULIC MORTAR.

[Translated from "Die hydraulischen Mörtel" of Dr. W. Michaëlis, for the Journal of the Franklin Institute.]

By Adolph Ott.

(Continued from page 285.)

Manger proposes the following excellent and simple experiment to ascertain the comparative quality of various descriptions of sand. He advises to form small heaps of sand on the bottom of a flat vessel, to pour water carefully around their base, and then to observe how the water rises in the heaps. Is the surface clean, the water will rapidly penetrate the sand in all directions, while if it contains earthy or clayey parts, the process will be much slower.

Wherever the sand at the disposal of the builder is found not to be sufficiently clean, it has to be washed; large quantities are best cleaned in vessels of $0^{m}\cdot 3$ to $0^{m}\cdot 5$, in lime chests, for instance. The sand must be thoroughly stirred up in water, and the latter then be rapidly drawn off, to be replaced by clean water, which experiment has to be repeated until the water flowing off appears clean.

Where sea-sand is used for structures above the water level, it must be carefully washed, in order to remove its saline parts, which would produce a strong effervesence.

All admixtures possessing considerably less hardness and solidity than quartz-sand, which soften in water, or become soluble in it, must be strictly avoided.

Pulverized glass, brick-dust and other substances have sometimes been used as substitutes for sand. Inasmuch as the first named materials possess an affinity to the quick-lime of the mortar, they may

safely be resorted to where sand cannot be obtained, as they acquire considerable hardness and solidity, provided the brick dust is of bricks burned hard.

Van Helmont and Kunkel already knew that glass is not altogether inaccessible to wet chemical agencies, and Scheele showed in the preface to his work "The Chemistry of Air and Fire," how considerable an influence is exercised upon glass by boiling water. His experiments, however, like those of Lavoisier, Chevreul and Barral, were confined to the influence of this agent upon glass vessels.

Taken all in all, this influence is only very minute. Lavoisier shows, for instance, that after an uninterrupted distillation of one and the same volume of water (which always flowed back into the retort), the loss of the vessel after 100 days was not quite one gramme; the influence of cold water upon compact masses of glass is still more insignificant. But it is different when pulverized glass is exposed to the action of water. Pelouze has made (in 1856) some highly interesting experiments in this direction.

Pelouze asserts, that a retort of the capacity of 500 C. C., in which water is boiled for five days uninterruptedly, hardly loses $0^{gr.}\cdot 1$ in weight; but if the neck of the retort is broken off, pulverized and exposed to the influence of boiling water for the same length of time, the decomposition of the glass reaches nearly one third of the entire quantity.

On the other hand, the same vessel, after containing water for years without being perceptibly changed, will, when pulverized, undergo a loss of from 2 to 3 per cent. by dissolution, when exposed to cold water only for a few minutes.

All glasses which form articles of trade, like looking-glass, window-glass, bottles, crystal and flint-glass, decompose gradually when pulverized and exposed to the air by absorbing carbonic acid: after a short lapse of time they effervesce vividly with acids, the development of carbonic acid becoming so great that one might be induced to believe he had a quantity of chalk before him.

If pulverized glass is boiled in water, and carbonic acid introduced, this gas is completely absorbed within a short time.

Griffith showed in 1826 that pulverized glass instantly imparts a blue color to litmus-paper and tincture: a proof of the immediate decomposition by water.

The facility of decomposition of glass by water alone shows that

pulverized glass forms an excellent admixture for lime, and that hydraulic mortar can be made with glass just as well as with trass and puozzolana. This has been proven by all experiments which we have made with pulverized looking or window-glass.

Moreover, Fuchs already says, that common glass is preferable to pitch-stone or pumice as an admixture to lime; it combines but slowly, it is true, but it finally gives a product which in solidity almost equals marble.

The same may almost be said of brick dust.

All descriptions of burned clay are known to be highly effective puozzolanas. Brick-dust, however, is nothing else but burned clay with a greater or smaller admixture of sand, which, from a chemical point of view, must naturally be considered as inert.

As regards the quantity of sand which may be admixed to hydraulic lime, it is dependent on the nature of the lime and cement, and on the object immediately in view.

It is impossible to lay down strict rules for guidance in such cases, especially not for the preparation of hydraulic lime.

In all cases, an experiment must be resorted to, to ascertain what mixture answers best for the object to be attained.

Portland-cement may be mixed with three to four times its quantity of sand, but this must be considered the extreme limit wherever it is intended for use in solid structures.

Considering that the intermediate space in sand amounts, on an average, to four-tenths of its volume, and that a compact solid mortar can only be obtained if every grain of sand is imbedded in a certain quantity of lime or cement, an admixture of three times the quantity of sand to one volume of lime or cement must appear to be the outside figure. Nevertheless, cement has often been mixed with a greater proportion of the admixture.

The slower the process of setting of pure cement, and the greater solidity it is capable of acquiring in itself, the greater proportionate admixture of sand it may be subjected to, as has been proven by numerous experiments.

Professor J. Manger says that by the mixture of

1 hectol. cement		and 0 hectol. 44 water	—0 hectol. 91 mortar is obtained
1 " "	1 hectol. sand	" 0 " 66 "	—1 " 83 " "
1 " "	2 " "	" 0 " 88 "	—2 " 78 " "
1 " "	3 " "	" 1 " 20 "	—3 " 80 " "
1 " "	4 " "	" 1 " 65 "	—5 " 01 " "

while according to Becker

1 hectol. cement		and 0 h[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1 " "	1 hectol. sand	" 0 "	[illegible]		1	1[illegible]
1 " "	2 " "	" 0 "	[illegible]			[illegible]
1 " "	3 " "	" 1 "	[illegible]			[illegible]
1 " "	4 " "	" 1 "	2[illegible]			[illegible]

The considerable difference in the above statements would not, in itself, surprise us, as we know by experience that the quantity of water required for the production of consistent mortar depends, in a great measure, on the peculiar nature of the cement; but what appears indeed remarkable is, that in the series of investigations by Becker, the pure cement requires one half more water than is set down by Manger; while, on the contrary, his mixtures with sand show a smaller quantity of water than appears in the statement of Prof. Manger.

In fact, the figures which follow below show, irrefutably, that Becker must have been misled in his experiments with pure cement.

If we assume that 100 parts of pulverized cement combine chemically with 19 parts of water, the solid mass is calculated as follows:*

0 hectol.	·91	mortar of the series of experiments by Manger	at	0	hect. [illegible]	70
1 "	·83	" " " "	"	1	"	42
2 "	·78	" " " "	"	2	"	13
3 "	·80	" " " "	"	2	"	[illegible]
5 "	·01	" " " "	"	3	"	[illegible]

From this we deduce a proportion of denseness of—

100 : 76·9,	while, according to Becker, the proportion would be	— 100 : 57
100 : 72·1,	" " " " "	— 100 : 77·7
100 : 73·0,	" " " " "	— 100 : 75·2
100 : 74·5,	" " " " "	— 100 : 73·0
100 : 71·6,	" " " " "	— 100 : 7[illegible]·6

If we leave the first of Becker's experiments out of the question, as it undoubtedly errs in the figures given, we find that the denseness of cement mortar is not increased by the admixture of sand up to three times its quantity, but is rather somewhat diminished.†

* One hectolitre pulverized cement weighs 121·3 kilo.: 23·05 kils. are consequently equal to 0·23 hectolitres.

† We speak here of admixtures of sand within the limit of 1 to 3 parts sand to 1 part cement; because, as we have mentioned before, the admixture of 3 parts sand must be considered the outside limit: if a greater proportion of sand is added, the denseness of the mortar will invariably be reduced. This has also been plainly proven by the experiments of Manger.

Experience has universally confirmed this proposition; we only know of one case where experiments had essentially different results; this was at Hâvre, where, since the construction of the docks was commenced, numerous experiments have been made, and it has been found (as reported by Dulk) that a mixture of one part of Portland-cement of White & Son and of J. F. Knight, with two parts of sand, produces the most solid and the densest material.

The report says: Since the construction of the dry docks has been entered upon (towards the end of 1858), constant experiments have been made on the building-ground to ascertain the precise quality of Portland-cement and the most advisable mixture, as it was also intended to make use of this material for the preparation of beton.* From each ton which had to be examined, a certain quantity of cement was taken, mixed in diverse smaller parts with various quantities of sand, and the mixtures put into brick forms. Each one of these was carefully marked with the date of the experiment, the description of the cement used, and the quantity of sand admixed. Of the product of each mixture two corresponding samples were kept, of which one was exposed to the air, the other to the influence of water for the purpose of hardening. After a certain lapse of time, dependent on the proportions of admixture and the degree of hardness to be obtained, the cohesive power of the samples, formed like a T, was first tried; then their comparative denseness was ascertained.

Small cylinders, of a diameter of 0^{m} ·10 to 0^{m} ·15 in height were formed, marked and numbered like the other samples, always two corresponding samples at each experiment, one of which was immediately laid under water, while the other was exposed to the air.

When the trial was made after a certain time, each cylinder was screwed in between two brass covers, closing so hermetically that no water could possibly penetrate between the covers and the cylinder. The upper cover had a hole in the centre into which a lead pipe, in connection with a higher situated water-reservoir was inserted; each one of the cylinders was thus subjected to the pressure of a water column of 5^{m}. Under each cylinder a tin box was

* As the pressure of the water is very great, the entire construction rests on a beton-layer, which has a thickness of 3^{m} ·58 in the middle, where only Portland cement has been used; this material has likewise been exclusively used at those parts which are mostly exposed to the pressure of the waves, while at other parts ordinary hydraulic lime was taken.

placed, into which all the water pressed through their sides had to flow.

After a considerable time, the water which had thus accumulated in the tin boxes was separately weighed, and the comparative proportion of denseness ascertained.

The result of all these tests are the following:

"A mixture of one part of Portland-cement with two parts of sand produces the most solid and dense mortar."

This, however, is so entirely contradictory to all experience that we are induced to believe no mixtures with other material but sand were ever tried at Hâvre, and that, as the proportion of two to one was the lowest quantity of sand admixed, it proved to give the best material.

(To be continued.)

PENNSYLVANIA'S FOUNDATION STONES.

Lecture delivered before the Franklin Institute, Thursday, Dec. 22d, 1870,
By Prof. Leeds.

The Position of Pennsylvania in the Geological Scale.

A CONTINENT was slowly sinking beneath the level of the sea. It was carrying down with it the fabric of an ancient world: a world of which we know but the little that can be gathered from the few fragments which remain. It was a world of granites and syenite, diorite and basalt, greenstone and porphyry—solid, compact and flinty. It was a world of wealth, of riches incalculable, but those riches were so locked up with bolt and bar, so fastened into the unyielding structure of the rock, so combined in obdurate compounds, that no strength of arm or even the chemist's skill could unlock them. It was a world of strength. Iron was there. Lead, copper, zinc, tin, were there. But, if mighty furnaces, that tower to the skies, and tax whole provinces for fuel, with difficulty extract from the pure ore its metal, how vain would be all man's toil, how hard and hopeless his lot, if nature had not already done for him the work of extracting these ores from the stony matrix. It was a world blessed with food and fertilizers of every kind. Almost every rock had potash and lime. The materials for plant and flower existed there—but hardly to be recognized—as stone. Enough, too, of sulphur and phosphorus, and phosphoric acid, to make all the nerve and fibre that plant and animal shall ever need,

but so united with harder stuff, so bound down with metal chains, that it would seem vain to hope that they could escape from bondage and rise to their appointed destiny.

But from the sea new life is born. So sang the Greek poets, and what then was a mere myth is found to be a sober truth of science. Time, so sang the Grecian seer, slew the god that in the beginning ruled over all things, named Uranus. He put an end to the heavens that were, to the order of things, then existing, and cast their remnants into the sea. From these remains sprang Aphrodite, whom the Romans, with their coarse and more brutal intellects, called Venus—the goddess that typified the reproductive and fertilizing energies of the earth. Do not your imaginations recall the exquisite picture—where the new-born goddess, with dainty arms raised above her head, and golden hair sparkling with pearly dew-drops, and eyes that languish love, is rising from the sea, her tiny foot just poised upon the crest of the waters.

The first continent that divided the waters from the waters was buried again in the sea, and from its ruins sprang all that ministers to or enjoys life.

I doubt if anywhere there exists at the present time a relic of this antique world of which I speak; at least, none whose claim to so great antiquity cannot reasonably be doubted. I think that all of us would give much to stand upon some fragment of this world. We know full well the interest with which we wander among the ruins of some ancient city. We examine curiously the marks of shot and shell which chronicle a bombardment of comparatively recent years. The narrow loop-holes in the watch-tower and the massive city gates carry us back to the middle ages. A few huge stones, that two thousand years have not been able to pull asunder, tell of the massive masonry of the Romans, while spears and hatchets of copper or of stone which have been dug up from beneath the soil, transport us to the infancy of the civilized races. But to stand on a spot that stood above the waters before any of these existed, before even the first beginnings of life itself, that were worth more than all—from this eminence to look down through the long ages, and behold country after country emerging from the deep, new forms of vegetable structure and higher types of animal life make their appearance, until man himself appears upon the scene, and the end of all things earthly approaches.

If any such spot exists, it is to be found on the American conti-

nent, and follows the present course of the St. Lawrence river and the boundary line which separates Canada from the United States. There we find a broad band of primitive rocks, granite, gneiss, syenite, hypersthene rock, porphory, labradorite, stretching to the northeast until it terminates upon the coast of Labrador, and to the northwest towards the Arctic Ocean. Some few outlying tracts, such as the triangular area included between Lake Champlain, the St. Lawrence and Lake Ontario, a part of Wisconsin and Minnesota, the Iron Mountains in Missouri, and the Ozark Mountains in Arkansas, may possibly date from the same remote period.

It is full of mineral wealth. It contains quartz, felspar of many kinds, hornblende, pyroxene, epidote, mica, crystallized in some localities in plates one and two feet square, talc, garnet, tourmaline, scapolite, wollastonite, sphene, rutile, graphite, apatite, chondrodite, spinel, zircon and corundum, and iron in greater abundance than in any of the rocks of later geological age.

I say that it is to be doubted whether these areas belonged to the ancient world—the world which crystallized out of the fiery mass of which I have spoken in my last lecture—for these Canadian rocks, the Laurentian Hills, as they are called, are made up of layers, one resting upon another. Granite succeeds gneiss, and gneiss reposes upon schist and limestone. Between these layers are other layers of iron ore, some of them a hundred feet and upwards in thickness, which are banded with silicious layers and chloritic schist, showing thereby a distinctly stratified character. Through all subsequent ups and downs of fortune, through every change and mutation, the evidence of this original layer condition of the strata has persisted, and may be recognized over great areas where the layers have been creased and twisted, and folded one upon another, until what has originally been horizontal has become vertical, and what was once the upper has become the lower surface of the layers.

There are some who see in these rocks the results of igneous action—products of the furnace, ashes turned out from the pit. Says Agassiz: "It may be asked how the materials for those first stratified deposits were provided? In later times, when an abundant and various soil covered the earth, when every river brought down to the ocean, not only its yearly tribute of mud or clay or lime, but the *débris* of animals and plants that lived and died in its waters or along its banks, when every lake and pond deposited at its bottom, in successive layers, the lighter or heavier materials

floating in its waters and settling gradually beneath them, the process by which stratified materials are collected and gradually harden into rock is more easily understood. But when the solid surface of the rock was just beginning to form, it would seem that the floating matter in the sea can hardly have been in sufficient quantity to form any extensive deposits. No doubt there was some abrasion even of that first crust; but the more abundant source of the earliest stratification is to be found in the submarine volcanoes that poured their liquid streams into the first ocean. At what rate these materials would be distributed and precipitated in regular strata it is impossible to determine, but that volcanic materials were so deposited in layers is evident from the relative position of the earliest rocks." There are "innumerable chimneys perforating the Azoic beds, narrow outlets of Plutonic rock, protruding through the earliest strata. Not only are such funnels filled with the crystalline mass of granite that flowed through them in a liquid state, but it has often poured over their sides, mingling with the stratified beds around. In the present state of our knowledge we can explain such appearances only by supposing that the heated materials within the earth's crust poured out frequently, meeting little resistance—that they then scattered and were precipitated in the ocean around, settling in successive strata at its bottom—that through such strata the heated masses within continued to pour again and again, forming for themselves the chimney-like outlets above mentioned."

The great objection to such an explanation is that it calls for the operation of forces entirely different from those which were concerned in the making of other rocks precisely analogous in their character. As we shall see, later, the entire thickness of the rocks which now cover the United States, and which, along the line of the Appalachians, amounts to the stupendous aggregate of 7 miles, or 10,000 feet more than the height of the tallest mountain now existing, was deposited quietly at the bottom of the sea. I do not mean that a sea 7 miles deep was quietly filled up until the entire surface of the United States made its appearance along with the last layer essential to its completion. Far from it. These 7 miles are made up in the main of hardened mud, consolidated sand and compacted limestone, alternating one with another in beds of layers which vary in thickness from a few inches to very many yards, and in extent from a few square miles to the dimensions of one or more states. Now, it is doubtful whether any limestone is deposited on a bottom

deeper than a thousand feet below the level of the sea, or mud where the depth exceeds two or three hundred feet, while sandy beds were formed, as we may see any day for ourselves, directly upon the shores of the rivers and the seas. Such *sedimentary* beds, as they are called, may be traced without any gulf or break from those which are being formed at the present time, and which are preserving in themselves the bones of the shipwrecked mariner, the spars and timbers of the stranded bark, the skeletons of plants and animals now existing, to other beds which entomb the remains of creatures that existed just prior to the advent of the human race. Beneath the last are others still less recent, filled with huge saurians, reptiles that dragged their horrid slimy length through shallow seas, or waged desolating war upon the inhabitants of marshes. Thence to times when much of the temperate zone, and Pennsylvania more particularly, was covered with a magnificent growth of club-mosses, equisetaceæ, and gigantic ferns. And even after we have arrived at the lowest forms of animal life, and find in the sediments mere molluscan remains, we discover in the nature of the rocks or sediments themselves so slight a clew, that there is no problem in geology more difficult or more warmly mooted as to which sediments are fossil-bearing, and those which are destitute of all organic remains. There is an area which begins in Pennsylvania with the Edge, South Valley and Conewango Hills. It broadens as it stretches southwards, and extends from a point to the east of Richmond until it reaches the base of the Allegheny Mountains. It includes all of the centre and western part of North Carolina, the hill country of South Carolina and the northern part of Georgia and Alabama. Your excursions about the city have made you familiar with the rocks which spread over this immense area. They are principally gneiss, or gneissoid in their character. That is, they are composed of quartz, mica and feldspar, arranged in layers. This layer-like arrangement, let me say more particularly, is the great characteristic, the minerals varying excessively. For sometimes the quantity of quartz or feldspar, and more especially the latter, is very small, and not unfrequently it is lacking altogether. Sometimes the quartz is milky and compact, at other times it looks like cracked and hardened jelly. The feldspar is often white and mealy, and then again there are places where you can pick it out in large flesh-colored slabs. Black mica, transparent mica, mica in spangles mica in great plates, mica scattered through the quartz, or feldspar

and mica massed together in beautiful crystals, all of these varieties, and more, too, can be found in the region of which I have spoken. I do not attempt to exhibit them here, because it would be as unsatisfactory to so large an audience to have their attention called to things which can only be seen plainly when held closely to the eye, as it would be to devote the valuable time which we can spend together to these minor details. But a stroll through our beautiful Park, and an examination of the rocks where they are exposed along the banks of the river, will give you an hour's pleasant occupation, and amply confirm all that I have said.

When your summer trips, for recreation or study, shall take you to the extreme southern border of this familiar rock province, you will be delighted to recognize in the romantic valley of Asheville and the French Broad river, and through the gap of the Swananoah, and around the bases of Mount Black, Mount Mitchell, and the eight sister peaks, just such mica, schists, and gneiss as you have hammered to pieces while geologizing in Delaware and Chester counties.

And here let me say a word concerning the powerful influence which the geology of a country, consciously or unconsciously, may have upon our home associations. The trees in the temperate climates, its beeches, oaks, maples, poplars, willows, pines and birches, are pretty nearly the same the world over. But the underlying rocks are very different, and I have always felt a great step nearer home, even though, when measured by the road, the way were longer, when I stepped off the fossil-bearing rocks, and found myself treading upon granites and schists and quartz rocks. And I distinctly remember with what pleasure, after fishing for weeks in the headwaters of the Roanoke and the James rivers, I left the great ledges of red sandstone belonging to the Devonian rocks of West Virginia, and found myself looking for minerals among the more home-like micaceous rocks of North Carolina.

These gneiss rocks of South-eastern Pennsylvania, and the gneiss country stretching, as we have already seen, so far south-westward as Alabama, are concealed from our view, as we go to the north-east, for a distance of 90 miles. They appear to have been depressed, probably at the time of the great disturbances which occurred, towards the close of the carboniferous period, over the whole of Eastern Pennsylvania, and probably a much wider area. The Atlantic Ocean rushed in over them, and their place was occupied by

a great gulf, the only vestiges of which at the present time are Delaware Bay and the harbor of New York.

A similar narrow gulf extended from somewhere about the southern State line of New Hampshire and Vermont, southward through Massachusetts and Connecticut, occupying nearly one half the latter State, and vastly more than the present valley of the Connecticut river.

These areas were slowly filled with lagoons and bayous, with marsh and morass, and were the homes of the most grotesque and formidable monsters that the world ever saw. Where now the quiet-loving inhabitants of Moorestown and Haddonfield, and the busy population of Phoenixville enjoy the mild serenity of uneventful lives, lizards and saurians of gigantic dimensions, some of them exceeding 40 feet in length, ran and paddled about.

On the eastern side of the Hudson, with the exception of the gulf of Connecticut previously mentioned, these gneiss rocks are found once more upon the surface, and continue on through New England and Nova Scotia to the Gulf of St. Lawrence.

After this lengthy explanation, we must return to our argument, which, as you will remember, was intended to show the improbability of the supposition that the similar rocks of Canada and Northern New York were the stratified deposits of submarine volcanoes. For it is, as I said before, with the greatest difficulty that the micaceous schists of Eastern Pennsylvania which contain no relics of animal and vegetable life can be separated and distinguished from those which do. And the same remark applies to the rocks of New England, and even of those rocks in Canada whose origin, whether from fire or from water, we are discussing.

The tendency of all the investigations which are being made at the present time is to lengthen out the period during which animals and plants have existed upon the face of the globe, and to include more and more of the rocks which were formerly regarded as Azoic among the life-containing. The rocks of Canada, and, still better, those of South-eastern Pennsylvania, afford a field for the study and settlement of this extremely interesting question—a better field, perhaps, than the rocks of any other portion of the earth's surface. The first great step, indeed, towards its solution was made through a careful scrutiny and a more critical examination than heretofore of the Canadian rocks, the rocks which, as I have previously said,

approach more nearly than any others to those which constituted the first formed solid crust of the globe.

They are divided by Sir William Logan, the Government Geologist of Canada, into the Laurentian and the Huronian. The former derive their name from the low line of the Laurentian Hills, and stretch, as I have previously mentioned, north-eastward to Labrador and north-westward to the Arctic Ocean. The Huronian include only a narrow band on the borders of Lake Huron, whence their name, and along the northern shores of Lake Superior. They are made of slates full of flint, of schists, massive quartz rock, limestones, and mixtures or conglomerates.

Their total thickness, according to Sir William Logan, is over 12,000 feet. If we add to these the Laurentian, which are probably 25,000 feet in thickness, we have the stupendous aggregate of 37,000 feet, or nearly as great a thickness of sedimentary rocks, deposited, as we have seen, at the bottom of the sea, during a time in which no life existed upon the globe, as of sedimentary rocks deposited later, at a time when it did.

And if we are to accept the theory of their igneous origin, we are compelled to believe in this enormous ash-heap, 37,000 feet in thickness, thrown out upon the bottom of the ocean. Thrown out, too, mark you, not only where we can see them as we do in Canada, and as some have believed, in Eastern Pennsylvania and along the entire eastern slope of the Appalachians, but everywhere forming the bottom of all the seas which exist at the present time, and concealed beneath the surface of all the continents.

Every year has witnessed some advance in our knowledge of the materials that make up the crust of the globe, which has weakened the probability of such a tremendous activity on the part of submarine volcanoes.

In the first place, although these rocks are largely made up of granites, quartz, marbles and other stones, which in some cases undoubtedly arise from the fiery mass filling up the interior of the globe, since they are found protruded through the most contorted cracks and dykes and fissures, which seem to split right down through the sedimentary rocks to the earth's core, yet the granites and quartzes alternate with mud, rocks and compacted sand. And what is still more at variance with the supposition that these granites and quartzes of the Azoic beds are furnace products, is that the quartz and feldspar and mica which, irregularly mingled to-

gether, constitute granite, assume more and more of a layer-like arrangement, until you pass by steps so numerous and so small that you cannot separate them, from a true granite to a true gneiss. And in the same way, from a hard flinty quartz to a sandstone, which looks as though made up of sand dug up from the sea shore. And from a highly micaceous schist to a hardened mud rock or slate, such as is now forming when every ebb tide brings down from the rich fields of Bucks county some of its soil and deposits it along the shores of the river.

A still more striking proof of the watery origin of these hitherto so-called Azoic beds is one which recently came under my notice. You may examine the matter for yourselves, by taking, any pleasant afternoon, a quarter of an hour's ride upon the Germantown Railroad, and getting out at Wayne Station. There you will find, on walking a few rods, until you arrive at the point where Wayne street cuts through a low hill, a most remarkable rock formation. The strata have been folded first into a deep trough, and then the sides and top of the trough have been squeezed together and folded one upon another, and finally twisted until one side of the trough is found above and the other beneath. So much for the curious phenomena, which I have examined many a time, and always with fresh interest.

(To be Continued.)

ON THE BALLOON AS AN INSTRUMENT IN METEOROLOGICAL RESEARCH.

(An abstract of a paper read before the Franklin Institute.)

By John Wise.

In the study of meteorology there is one means of investigation which is capable of marvellous development, and which, as yet, has not received a tithe of the attention of which it is worthy. I refer to the balloon. Meteorology has as yet but feeble claims to the name of Science, nor, until some mode of research is devised that will bring the student of atmospheric phenomena into closer relation, into more direct contact with the problems he would solve, can we hope for more rapid progress than we make at present. The air-ship must furnish us with the solution of the problems, at which we can now but venture to guess—for it is the only means which is com-

petent to meet the imperative wants of the investigator; it alone can bring him face to face with, and in the very midst of the mysteries of his subject. It is to meteorology what the water-ship is to hydrography, and in their respective departments one can be as little dispensed with as the other. The little that we know of the subject serves as far as it reaches to justify the comparison. The deep sea soundings, so pregnant with interest in their revelations of infusorial life at the bottom of the ocean, have been met with the deep air soundings, revealing to us vegetable myriads, which make the upper air their highway.

Is it not a marvel then that a field ripe for the sickle waited so long, and waited in vain for the harvester? It will be objected that the mode of investigation is a dangerous one; but, with the experience of many years to warrant the assertion, the writer feels safe in stating that this opinion is wholly erroneous. It has its origin partly in the novelty of the means employed, and partly in wilful misrepresentation. If one who is interested in the subject will take the trouble to institute a comparison between the number of recorded air voyages and the accidents incident thereto, a result will be obtained as favorable as the most sanguine admirer could claim for ocean travel. As an extreme instance, the following may be of service to meet the objection under consideration. The writer has circumstantial accounts of thirteen balloon explosions (in two of these he was a participator) which occurred at considerable elevation—from 5000 to 15,000 feet—and in none of these instances were any of their occupants harmed.*

* On the 11th day of August, 1838, the writer made an ascension from Easton, Pa., with preparations to explode his balloon, for the purpose of demonstrating that an exploded balloon would form a *parachute*, and thus descend with its occupant without serious injury. Accordingly, when an altitude of about 13,000 feet was attained, the balloon became fearfully expanded—to its utmost tension; and, having a neck tube but an inch diameter for the lower safety valve, the gas began to issue therefrom with considerable noise. The *exploding* cord (an invention of the writer) being tied short, had also become tensely stretched, and was tending towards a rupture. At the points it passed through the top of the balloon. As the ship was at the time immediately over a thundergust raging some eight or ten thousand feet beneath, it was with considerable trepidation that the critical experiment of the explosion was decided upon. Taking out his watch, twenty minutes past two was noted on the log-book, and as it was returned to its fob, the *balloon exploded.* The gas rushed through the large aperture, ten feet long, with a tempestuous noise, and in ten seconds the balloon was empty. The descent was rapid at first, but the ship soon came to a uniform velocity, and the landing was effected safely in a clover field, after having crossed a piece of wood land by dis-

The law of atmospheric resistance is as invariable as that of atmospheric buoyancy, and with the large expanse of material present in a balloon, and the very nature of its construction, it is scarcely conceivable that in falling it should offer so little resistance as to descend with destructive or even dangerous speed.

Nor is the ship, even under such unusual circumstances, unmanageable. So far as the writer has investigated the cause of accidents with balloons, not a single instance was found to be assignable to any dangerous element peculiar to, or connected with the art of ærial navigation. The water-ship has two elements with which to contend—the water, nearly a thousand times denser than air, the winds, with the velocity at times of an hundred miles per hour: these, combined with the immense mast leverage, must cause terrific strain upon its framework when in the grasp of the storm.

posing of ballast, and drifting with the wind. As near as the descent could be timed, it occupied four and a half minutes.

The following curious note was received next day. The writer was a stranger.

"NEW VILLAGE, August 11th, 1838.

"Mr. Wise, Master of the Ærial:

"I hereby certify, that my first sight of your air-ship was north of Henry Snyder's; it then apparently passed not far from William Kinney's, then directly between the inhabitants of New Village and the sun; we saw the gas rushing from the balloon like the steam from a boiler; it created between us and the sun the colors of the rainbow, and it was some time before we got a second sight, when you appeared to be lowering. As the size of the balloon became larger, we could discover a black spot underneath, about twenty feet. I pursued on foot until I saw you alight near Thomas Thatcher's.

"From your most affectionate, but not acquainted friend,

"WILLIAM SHARPS.

"N. B. and others."

In the month of October following the writer repeated the experiment from Philadelphia. It was publicly announced to take place from the corner of Seventh and Callowhill streets. Prof. Mitchell, of Jefferson Medical College, strongly advised the omission of that part of the announcement, but the author mentioned in reply his confidence in atmospheric resistance, and his determination to repeat the experiment. The following is one of a number of newspaper notices of the occurrence:

"Mr. Wise, the æronaut, made a successful ascension on Monday (October 1st, 1838). The balloon passed over the Schuylkill, and Mr. Wise eventually descended, according to his promise, by letting off the gas gradually [this is a mistake, it was let off suddenly,] at an extreme height, by means of a cord and pulley, [there was no pulley, it was simply a cord to rip the balloon with at its top.] he converted the balloon into a parachute, and thus came down. It was a most fearful undertaking, and was anticipated by competent scientific authority as calculated to carry with it destruction of life."

Not so with the air-ship; it has but one element to conquer, and once freely suspended in the ocean of air, it matters not, so far as its capacity to withstand a strain is concerned, whether the wind moves at the rate of one mile or one hundred miles per hour. Even with the latter velocity, the vessel glides along so smoothly that a cobweb suspended from its flagstaff is undisturbed by the slightest ruffle. Were it not for the fact that objects on the earth are seen to approach and to recede, it would be impossible to detect the motion of the ship, with such marvellous stability and quietude is even this immense velocity accomplished.

The same rules which apply in securing safety to our ordinary mode of voyaging are ample in the method under consideration. The accidents which occur with balloons are in every case attributable either to deficient construction or to an absence of ordinary skill and prudence in the persons operating them. It is a deplorable fact that, with rare exceptions, those who are adepts with the balloon are not scientific, and it is this class who are especially fond of relating marvellous accounts of their physical agonies—of the fantastic tricks of their vessels, and their hair-breadth escapes. Let me hope that sufficient has been said and accomplished to prove that we can ascend into the air, into the cloud, into the storm, by day or by night, to investigate the phenomena of the atmosphere, without incurring the accusation of being reckless if we but turn our eyes of yesterday, when high officials of state sail from beleaguered cities in the air-ship, and governments use them as mail route agencies to distribute their daily mails.

To the Franklin Institute should the honor be assigned of establishing a Section of Meteorology, to explore the mysteries of the atmosphere with the aid of the air-ship and suitable apparatus. The cost of construction with modern facilities has ceased to be a drawback, and the establishment of gas works has greatly lessened the expense and inconvenience of inflation. And with such men as Dr. Wahl, our efficient Secretary, and his co-laborers in science, to undertake the investigations, and with an experienced air navigator to command the ship, a year would suffice to collect a series of facts which might go far toward deciding authoritatively matters which are now obscured in the mists of doubt and uncertainty. The services of the writer—if his experience is deemed of avail—would be most cordially offered.

We owe such a course of investigation to the age in which we

live. The progressive spirit of science demands earnest toil from her disciples, and calls for generous nourishment from institutions of learning, and none are better fitted to meet her claims than the Franklin Institute.*

Once properly put in motion, it would not be long before those who now scout the idea of crossing the oceans and circumnavigating the globe with balloons would be as solicitous to make their tours of recreation and scientific investigations in them as they are now to doubt its feasibility.

OBSERVATIONS ON SIEMENS' UNIT.

By F. Kohlrausch.†

The universal adoption of a galvanic unit of resistance will be decided by its introduction into and general acceptance in telegraphy; and there is little doubt but that here Siemens' mercury unit will hold possession of the field. The benefits accruing to scientific galvanometry by the introduction of his readily comprehensible and convenient scale of resistance has received general acknowledgement and praise. It may therefore be regarded as meeting that solution of the question of resistance which, in the discussion of the subject by the British Association, so many eminent physicists regarded as desirable. There exists, consequently, in the interests of Physics, the pressing need of fixing with all possible accuracy the relation between Siemens' and Weber's absolute unit. To the last mentioned scientist we are indebted for four methods of determining absolute resistance according to Ohm's law. Three of these methods were applied by Weber himself, while the fourth has been brought into use by the investigations of the British Association, instituted to determine the absolute unit.

The first method consists in making use of the electro-motive force induced by the earth's magnetism in a conductor in motion, the dimensions of which are given. The strength of the current is

* A meteorological section has for some time been organized in connection with the Institute, and has been very warmly supported. The object which the author so ably advocates may, when the resources of the section have grown sufficiently to warrant the undertaking, be practically carried into execution.—W. H. W.

† From the Reports of the Royal Academy of Göttingen, November 23d, 1870.

determined by the deflections of a small magnetic needle of known oscillating capacity, suspended within the coils of a galvonometer of known dimensions.

In the second method a galvanometer is employed within which a larger magnet oscillates. If we have ascertained the time of oscillation of the needle; if likewise by observation of the deflections of another needle we have ascertained the relation existing between the magnetism of the needle and that of the earth; and if the capacity of distribution of the former is known, it is evident that the electro-motive force created in it by the needle may be calculated, as from the dimensions of the galvanometer. The strength of the current hereby induced may be estimated by the observed steadiness of the needle.

The third method demands a knowledge of the coil surface of an earth inductor, and the absolute intensity of the earth's magnetism; and an astatic needle oscillating between close coils serves as a galvanometer.

In the last method, a bobbin of known dimensions is set in rapid and uniform motion, and the deflection of a needle suspended within, is observed.

Weber has used the first and second, and lately the third method, to determine absolute resistances. The last has been brought into use by the standard commission of the British Association. Concerning this fourth method the following may be added. It has, namely, two modifications: the inductor may be rotated either about a horizontal or about a vertical axis, and in either case difficulties are combined with the attainment of a rapid and uniform rotation. In the first case the relation of the horizontal to the vertical component of the earth's magnetism must be ascertained; in the second, a disturbing inductive effect is produced by the magnetism of the needle, which must be artificially eliminated. The last method, the rotation of the inductor about a vertical axis, is the one adopted by the British Association, and their measurements possess greater simplicity and accuracy, from the fact that the process is independent of a knowledge of the earth's magnetism. Other defects are, however, very perceptible, and as the question arises whether and in how far the arranged execution of Weber's $\frac{\text{earth's-quadrant}}{\text{second}}$ by the British Association is a solution of this question, it will be necessary to consider the subject in detail.

In order, by aid of a co-efficient of correction, to eliminate the currents induced by the needle, the magnetism of the latter was made very weak—a condition which, it is probable, has never existed in similar tests. The magnet was a steel ball, of a diameter very nearly 8 millimetres, and a mass therefore of about 2 grms., and this unfavorably shaped mass was not magnetized to saturation. In fact, a reference to the figures stated in the Report of the British Association * will prove that the magnetism of the ball was less than that which may be communicated to a common needle weighing 0·1 grms. This circumstance will explain why a single fibre of silk 8 feet in length was necessary in order to reduce the torsion to a minimum. To this tiny magnet was united a mirror 30 millimetres in diameter on a metal wire 0·25 metres in length, affording therefore a surface of 14 sq. centimetres for air-currents. That the moment of inertia of these attachments could not have been small, is evident from the fact that the oscillating period of the system was more than 7 seconds, while that of the needle alone would have been about 1·5 seconds.

The British Association Reports give us only average values, deduced from many observations; we are therefore deprived of the data for determining any irregularities which may have been caused by the feeble magnetism of the needle. But even these results present large differences.

Thus resistances found by deflections in opposite directions differ from each other as much as 8 per centum,† which is equivalent to an inequality of 20—30 divisions of scale in the deflections to the right and left.

The intimation of Mr. Jenkin ‡ that the differences originated in an unequal or one-sided influence of the fibre is not admissible, for a torsion of such considerable influence in a fibre of such length cannot have existed.

The mean values taken by pairs reduce the differences to 1·4 per centum, but they still premise either errors of adjustment or in reading off the scale, to account for their presence.

If, therefore, we find such irregularities in the mean values of half-hourly observations (from which extraordinary deviations || have even been excluded), if, further, the uniform rotation was in

* 1863, p. 172. † *B. A. Rep.* 1864, p. 350; *Pogg. Ann.* CXXVI, 386.
‡ *Pogg. Ann.* CXXVI, 387; || *B. A. Rep.* 1863, p. 174.

all respects satisfactory;* then other unknown, but important sources of error must have been present; and it is not improbable that they are to be sought in the feeble magnetism, and perhaps the spherical form, of the magnet.

Another matter is, however, to be considered. Though the experiments were carried on with much intelligence, and though the theory of the corrections as stated is a model of completeness and elegance, one point is not at all approached. The stand on which the inductor rotated consisted of "strong brass frames," which, as may be seen from the drawings,† formed closed circles. We are nowheres told whether the currents induced in these stable portions of the apparatus by the rotating conductor were inconsiderable; nor are we told why they were assumed to be so. This would, it is true, be most difficult, perhaps impossible, to prove by actual experiment, but on this very account the proximity of these masses of metal is calculated to awaken distrust.

I will mention finally an objection originating with W. Siemens against the practice of deducing from the length of the wire, the mean diameter of the coils.‡ I have convinced myself that with wires whose section amounted to as much as 4—5 sq. mm., the practice is entirely reliable, but in the present case where the wire is but about 1 sq. mm., I dare not venture an opinion.

From a compilation of their separate results|| this commission announces a probable error in their final conclusion of 0·08 per cent. The skill, labor and care which would detect so trifling an error, springing from pure accidental sources deserves the fullest recognition, but the unit they have established can receive no acceptance from physicists, until the absence of constant sources of error has been proven. To this end, perhaps, a more detailed publication of the methods and materials of their observations might be of service; and this is, from the fundamental character of their research, much to be desired. As it is, however, the labor of the commission is a classical one, and their theoretical and practical observations in the determination of absolute resistance are of the greatest value to science.

In the same way I shall next endeavor to view the third method by which the following results have been obtained, as regards its difficulties. A quantitative estimate of these difficulties seems,

* *B. A. Rep.*, 1863, p. 120. † *ibid.* p. 164.

‡ *Pogg. Ann.*, CXXVII., 333.

|| *B. A. Rep.*, 1864, p. 350. *Pogg. Ann.*, CXXVI,, p. 386.

too, not out of place, in view of the fact that existing opinions concerning the exactness of absolute resistance tests widely differ.

Absolute resistance may be determined from observation, not regarding co-efficients of correction by aid of the following formula:—

$$w = \frac{8\ \text{s}^2\ \text{T}^2\ t,\ \log.\ \text{nat.}\ \frac{a}{b}}{\text{K}\left(a\sqrt{\frac{a}{b}} + b\sqrt{\frac{b}{a}}\right)^2}$$

I will assume that the errors of these separate magnitudes have been determined, to within the following fraction of the whole magnitudes, viz:—The coil surface of the inductor s, to within $\frac{1}{2000}$. The intensity of the earth's magnetism to within $\frac{1}{1000}$. Duration of oscillation t to within $\frac{1}{3000}$. Moment of inertia K to within $\frac{1}{750}$; and that the deflections on the scale shall be correct to within 0·2 mm., while in our experiments their values were 370 and 225 mm. The error then of a single observation in which all the single values should add up most unfavorably, would amount to $\frac{5}{8}$ per cent. According to the calculation of probabilities the error would amount to $\frac{1}{3}$ per cent. I call especial attention to this possible maximum, since according to my results the B. A. unit is almost 2 per cent. too large.

A very considerable portion of the above mentioned error arises from the uncertainty of determining the intensity of the earth's magnetism. From this it follows that a successful determination of absolute resistance, can only be made with the aid of the most perfect instruments for measuring intensity; such, for instance, as those now in possession of this University. Where these aids are not to be had, another method, for example the first, might give more accurate results.

With reference to the actual execution of the measurements a few points deserve mention for the sake of accuracy.

Two sets of Siemens' units, each of 4 units, especially made for Dr. Siemens' were at hand. The resistance of the circuit (inductor and galvanometer) was brought to nearly the same amount. Before and after every absolute test the last was compared with Siemens' units. Especial labor was bestowed in the determination of the intensity of the earth's magnetism. Two determinations of this

* *Pogg. Ann*, CXIII., 310–11.

factor made during the progress of the observations (6 days), after reducing to the same level the instruments of variaties, gave very close results, the difference being less than 0·02 per cent. M. Riecke carried out the observations of variations during the measurement of intensity as also during those of resistance.

The periods of time were measured upon the clock of the University, the weights used were a set of Fortius, the tests of length were made with a platinum metre in possession of the department of engineering, and the graduations of the paper scale used were subsequently compared with each other.

The comparisons of the resistances was accomplished by simple branching of the current in a double coiled galvanometer; but the currents employed were not as usually used, hydro-electric, but short ones induced by Weber's magneto-inductor.

The employment of weak induced currents effectually prevented any heating effect: and the alternation of the direction of the currents eliminated at once all effects of any possible existing thermo-electromotive force. On account of the slight inequality of the resistances to be compared a 0·1 Siemens was interpolated.

It appears to me to be indisputable that such a combination of induced currents, with methods adapted to compare resistances, must offer great advantages in point of convenience as well as in accuracy.

As a proof of the care and exactness with which Siemens units are adjusted, I may mention that the two latter ones, at the temperature marked upon them, should have a proportion 1·00044. From comparisons with a third set, I found that proportion to be 1·00050, 1·00046, 1·00055

The results of the observations consist in three determinations of Siemens unit according to absolute measure. It was found that—

$$1 \text{ Siemens'} = 0{\cdot}9705 \ \frac{\text{earth's quadrant}}{\text{second.}}$$

$$1 \text{ Siemens'} = 0{\cdot}9608 \quad \text{"}$$

$$1 \text{ Siemens'} = 0{\cdot}9713 \quad \text{"}$$

So that the mean value of the Siemens' unit is equal to 0·9705 $\frac{\text{earth's quadrant}}{\text{second}}$, or equal to 9705000000 $\frac{\text{mm.}}{\text{sec.}}$. M. Herman Siemens was kind enough to compare the Siemens' with the B. A. unit (the property of Dr. Weber and Dr. Brix), the result was—

$$1 \text{ B. A. unit} = 1{\cdot}0493 \text{ Siemens;}$$

which value, with the necessary reduction, agrees almost exactly, with Mr. Jenkin;* so that 1 B. A. unit $= 1{,}0184 \frac{\text{earth's quadrant}}{\text{second}}$.

As important as it is in practical tests of resistance to know the absolute value of the Siemen unit, so great also in the measurement of currents is the necessity for an accurate knowledge of the constant introduced by M. Weber, the electro-chemical equivalent of water. This permits of absolute measurement of currents with the voltametre, but is only exact to within one per cent. This determination was likewise undertaken and carried out; but unfortunately the toilsome task was fruitless, owing to the local influence exerted by a brass screw in the damper of the tangent instrument, which was not noticed until too late, and the disturbance created was too great to be eliminated.

ON A METHOD OF FIXING, PHOTOGRAPHING AND EXHIBITING THE MAGNETIC SPECTRA.

By Alfred M. Mayer, Ph.D.

The figures produced in iron-filings, when these are set in momentary vibration on a surface placed over a magnet, have received considerable attention from natural philosophers. The geometrical discussion of these spectra made by Lambert, Roget and others, have developed their symetrical properties and thereby have evolved the law† of that action which emanates from the magnet. De Haldat has used them as a means of exploring the distribution and intensity of the effect of juxtaposed magnets variously arranged. But, above all, have the researches of Faraday and W. Thomson on "the magnetic field" and on "the lines of magnetic force" given to these spectra—even when merely regarded as conventional symbols—an importance which has been fully shown, especially by Faraday, who was guided by their consideration to some of his most important discoveries. They have thus risen to so high a theoretical importance that a method which will fix them without danger of distortion, photographically repro-

*Pogg. Ann., CXXVI., 382.

†See a neat "Démonstration par le calcul des courbes magnétiques de la loi de l' inverse du carré de la distance," by M. Cellerier, published as a note on p. 592, Vol. I., of De la Rive's Traité d' Electricité.

duce them, and readily serve to exhibit them to the largest audiences, will, I imagine, be acceptable to both investigators and lecturers.

The only process of fixing these spectra, known to me, is that practiced by De Haldat and Faraday, which, however, is but an application to the magnetic spectra of the method previously invented by Savart for preserving the Chladni figures of vibrating plates. In this process the spectra, produced in the usual manner either on glass or card-board, have pressed upon them a sheet of paper coated with mucilage to which the filings adhere. In this operation of the transfer many particles are deranged from their positions and the figures are yet more distorted by the shrinkage of the wet paper, and are therefore not fit to serve in measures of precision; while the impressions cannot be exhibited with much more facility than the originals.

My process is as follows: a clean plate of thin glass is coated with a firm film of shellac, by flowing over it a solution of this substance in alcohol,* in the same manner as a photographic plate is coated with collodion. After the plate has remained a day or two in a dry atmosphere it is placed over the magnet, or magnets, with its ends resting on slips of wood, so that the under surface of the plate just touches the magnet. Fine iron-filings, produced by "draw-filing" Norway iron which has been repeatedly annealed, are now sifted uniformly over the film of shellac by means of a fine sieve. The spectrum is then produced on vibrating the plate, by letting fall vertically upon it, at different points, a light piece of copper wire. The plate is now cautiously lifted vertically off the magnet and placed on the end of a cylinder of pasteboard, which serves as a support in bringing it quite close to the under surface of a cast-iron plate (1 ft. diam., $\frac{1}{2}$ in. thick) which has been heated over a large Bunsen flame. Thus the shellac is uniformly heated and the iron filings, absorbing the radiation, sink into the softened film and are "fixed."

I generally allow the heat to act until the metallic lustre of the filing has disappeared by sinking into the shellac, and the film appears quite transparent. This degree of action is necessary when photographic prints are to be made from the plate, but when they are to be used as lantern slides I do not carry the heating so far.

* The shellac dissolved in strong alcohol is allowed to stand a week or more, and the clear supernatant solution is then decanted.

After the plate has cooled, it is allowed to fall upon its edge on a table, so that any filings that have not adhered may be removed.

A short experience will give the proper strength of shellac solution to obtain a film so thick as *just to be sufficient to hold the filings*, and the requisite amount of heat to firmly cement them without injuring the transparency of the film.

The plates can now serve (1) for the most accurate measures upon the magnetic field; (2) for a photographic positive, which, in the printing-frame will produce the lines in white upon a dark ground, giving most beautiful and distinct impressions;* (3) or, if it is required to exhibit these figures to an audience, the plates are provided with glass covers, kept from touching the spectra by intervening slips of card-board, and there result "slides," in every way fit for giving a fine exhibition when the images are projected upon a screen. I have thus obtained images, clear and sharp, of over 12 feet in diameter.

By this process many plates have been produced,† showing the action of single magnets of various forms, and of juxtaposed bars: as well as the effects of electric currents led by wires through holes drilled in the plates. Those exhibiting the inductive action of magnets on bars of soft iron and the interaction of magnets and electric currents are peculiarly interesting. An approximate representation of the resultant line of the terrestrial magnetic action has been obtained by magnetizing *equally tempered* steel discs of from 2 to 3 inches, and even more, in diameter. The magnetic axis, or axes, of these discs being *predetermined* by making them the continuation of the axes of powerful electro-magnets whose poles are conical projections with slightly rounded apices. The arcs of the great circles, including the terrestrial magnetic poles, having been calculated, the axes of the electro-magnets are inclined at that angle, while the steel disc is held close to their poles. On passing the current the disc is magnetized, and we have an approximate representation of a section of the earth's magnetic effect. These results when viewed as photographic prints, or, as exhibited by the lantern, are as beautiful and instructive as to appear to me to warrant this somewhat formal description of the process of their production.

* Photographic prints from a series of eight of these plates I have presented to Harvard College, American Academy of Sciences, Sheffield Scientific School, Columbia College, Stevens Institute of Technology, Hoboken; Lehigh University, Pa.; American Philosophical Society, Franklin Institute, Peabody Institute, Baltimore; Smithsonian Institute, Chicago Academy of Sciences, and to the University of Virginia, where they can be examined by the readers of this paper.

† Many of these are 16 inches long by 10 inches wide.

Bibliographical Notices.

Report of Committee of the Trustees of the Rensselaer Polytechnic Institute, concerning the System of Instruction, with proposed modifications.

In obedience to a peculiar demand of American civilization, the minds of educators have been largely engrossed the past ten years with the subject of Technical education, in connection with modern literature, as opposed to what is usually comprehended under the term of a strictly "classical education."

While a great deal can be said on both sides as to the mental training given in each system, apart from any material considerations, there is no question that the advocates of the New Education are rapidly gaining ground, as shown by the establishment of technical schools throughout the States, either independent or attached to the older colleges. The pioneer school in this new education, as is well known, is the Rennselaer Polytechnic Institute, at Troy, established primarily for the student of natural science, but rapidly expanding in a technical direction, it has become the leading school in this country—a proud distinction that more than one competitor is endeavoring to wrest from it. The Troy school, with no endowment, has won its position through exacting the highest requirements from its students, and combining with a rigid theoretical instruction a large amount of actual practice. It has struggled through difficulties that would have deterred from further effort almost every other institution, and it is to the credit of its trustees and faculty that they have brought it so nearly to a perfect success.

In furtherance of the desire of the trustees to increase the usefulness of the institution, a committee from their number was appointed last March to examine into the present course of instruction, and report if it were desirable to modify it in any particulars, in order that it might conform to the most advanced state of Technical Science. This committee (consisting of Messrs. E. Thompson Gale, A. L. Holley and C. E. Dutton) have just issued their report, which is certainly one of the most valuable contributions to the cause of technical education ever published in this country. Without restricting their researches to the opinions of professional instructors in various portions of the United States, they have obtained ideas

from those actually engaged in practical life. These letters are placed in an appendix, and are from such men as Messrs. A. S. Hewitt, S. M. Felton, Robert Briggs, Wm. Sellers, J. Vaughn Merrick, Gen. McClellan, Gen. J. G. Barnard, &c., &c. The consequence of this business-like procedure, the committee had before them an amount of valuable opinion based upon experience, that enabled them to point out the wants of the Institute with a confidence in the result obtainable in no other way.

After some preliminary remarks, defining the position of technical schools (as typified in the Institute) in relation to the needs of young men after graduation, the report gives an outline of the course of instruction adopted in foreign technical schools, selecting for illustration that of "Carlsruhe," noted for its comprehensiveness. Until government thinks it to be a duty to undertake the higher education of its citizens, it is impossible for any school in this country to attain the perfection of a German school. In Germany education is a system, one school depending on another—a harmonious gradation carrying the pupil from the public or common schools up to the university or polytechnic school—the one almost purely literary, the other purely scientic or technic.

While lamenting that we never in this country can attain the educational harmony of Germany, we can do much in localities, in so far as local governments can control local schools, and make them to be operated as part of a progressive educational system. In this view, the committee have recommended in their report that the trustees should request the city authorities of Troy to co-operate with them in making the High School a preparatory school for the Institute, as well as being as it is now, merely a preparatory school for college. It must be remembered that technical schools require as much preparation in the student as do colleges, and in some particulars more. It is impossible for a technical school to pay that attention to literary attainment which every young man should possess to a certain extent, and which can only come from a preparatory school in full accord with the higher education which is to follow.

To touch upon all the topics so ably discussed in this report would hardly be possible in a brief notice. Careful examination is bestowed upon all the leading branches of a scientific education, with the deductions resulting therefrom. Special emphasis is given to the importance of more than text book instruction on steam and its appliances, since there is no branch of the engineer's profession

where steam is not applied in some shape or form. Power is daily superseding hand-labor, and it is one of the tools that every engineer must work with. Although the civil engineer is not called upon to make machinery, he daily uses it, and should be thoroughly acquainted with the principles that govern its application. A staff of non-resident professors is recommended, experts in some specialty of engineering, who should at stated times deliver one or more lectures upon such points of practice as their own experience would dictate, and which it is impossible for the regular professor having charge of the course to cover. That the recommendations of the committee should be carried out there is no question, and when this is done it must result in keeping the Rensselaer School in the van of progress among those Institutions devoted to Technical Education.

It is hoped that this brief notice of a valuable report will serve to attract the attention which it deserves among the friends of the Institute, as well as all those interested in the developments of the "New Education."

A. P. B.

Elements of Machine Construction and Drawing. By S. E. Warren, C. E., Professor of Descriptive Geometry, etc., in the Rensselaer Polytechnic Institute of Troy, N. Y.: J. Wiley & Son, N. Y., 1871.

This work is on a new plan and enriched by many examples of present engineering practice from the best sources, making it a helpful book to the student, and to the practical man.

The kind of information most needed and prized by the latter consists of well proportioned details of operative mechanism drawn to a scale or in figured outline sketches, accompanied by notes on the performance, strength, material, fitness, durability, efficiency, &c., of the same.

We find a liberal share of such facts in the book before us, and are glad to see a treatise not only recognizing the connection between the principles of mechanism and the organs themselves properly proportioned for transmission of power, but giving abundant examples from modern shop practice for studies in lieu of the oft-repeated, ill-designed pictures of the old philosophy books.

We never could understand why good practice should not be associated and studied in connection with right principles and to our practical mind the perfect working machine is the machine constructed on sound principles.

Prof. Warren's classification of machines on the mathematical basis is the simplest and most comprehensive of which we have knowledge, and believe it must take precedure over all other efforts in this direction.

This treatise is amply illustrated by woodcuts in the textural part, and is in addition supplied with an atlas of folding plates.

J. H. C.

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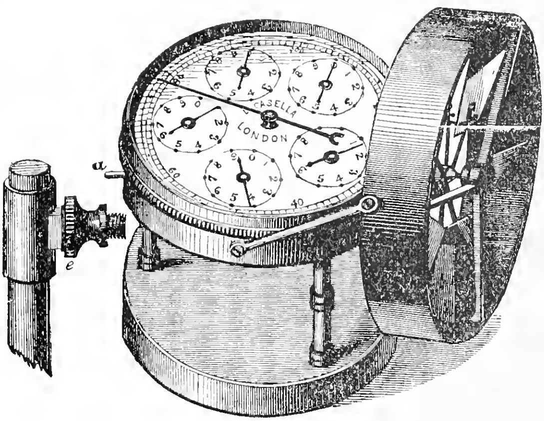
EDITORIAL.

ITEMS AND NOVELTIES.

Fire-proof Safes.—At the last meeting of the *Franklin Institute*, a new device for increasing the fire-proof quality of safes, and of affording additional safety to papers and other valuables stored in them, was exhibited. The improvement which is claimed is effected by placing water in copper vessels between the inner walls of the safe and the book-case: so that when exposed to fire, steam is generated, in which act a large share of the heat is absorbed, and the contents of the safe protected for a considerable length of time from the effects of an elevated temperature. The vessels are hermetically sealed with a fusible solder, which melts and opens the steam valves just before the water boils, but which effectually prevents evaporation, keeping the safe dry till the fire occurs. Return tubes, ingeniously arranged, preserve the water from running out, in the event of the safe falling on its side or top in burning.

The principle here relied upon to increase the efficiency of safes, is the property which water more than all other bodies possesses, of absorbing heat in the act of becoming steam. The action of the vessels is designed to be that the steam shall convey the heat from the safe as rapidly as it is given to it; no more heat being left to penetrate through the water vessels than is needed to produce the steam capable of being generated by it.

Castella's Air Meter.—The accompanying illustration represents a very useful and compact form of air-meter, designed and manufactured by Castella, of London, the object of which is to give correct means of measuring the velocity of currents of air passing through mines, the ventilating spaces of buildings, &c. It was first constructed for Dr. Parkes, F. R. S., for the purpose of measuring the state of ventilation in one of the government establishments in England, and with such good results that it has been extensively introduced in that country and elsewhere for a similar purpose. One of these instruments, imported, amongst other things, for the Stevens Institute of Technology, was exhibited at a late meeting of the *Franklin Institute*, and elicited general admiration for its extreme delicacy.



The graduations for each instrument are obtained by actual experiment by means of machinery made for the purpose, so that the indications of all are as comparable with each other as the weight or measure of ordinary substances.

The indications are shown by means of the large dial and hand and five smaller ones, as shown in the annexed figure. The whole circumference of the large dial is divided into 100 parts, and represents the number of feet up to 100 traversed by the current of air. The five smaller dials are each divided into ten parts only, one revolution of each being equal to ten of the preceding dial, and

representing 1000, 10,000, 100,000, 1,000,000 and 10,000,000 respectively. By means of the large dial the low velocity of fifty feet per minute may be measured, and by the smaller ones continuous registration is extended up to 10,000,000 feet, or equal to 1893 miles; being practically beyond what the most extended observations can require, whilst jewelling in the most sensitive parts insures the utmost delicacy of action.

By moving the small catch *a* backwards or forwards the work is put in or out of gear without affecting the action of the fans: this prevents the injurious effect of stopping them suddenly, and enables the observer to begin or end his observations to a second. A small handle with universal joint accompanies the instrument, and may be screwed in at the base; by putting a stick through this, it may be raised or lowered to any required height and used in any position.

The Nicaragua Route.—The pages of Col. O. W. Childs' Report on the Survey of the Nicaragua Route for a Ship Canal still remaining unpublished in our columns, we believe to be of such a character as would prove uninteresting to our readers, and the further publication of the report will therefore be discontinued. What remains consists entirely of details, mainly tabulated, of earthwork, dams, etc., with estimates of the cost of the separate portions of work. As the whole of the general report has been reproduced in full, together with the cost estimates for the several branches of the work, and of the total expenses, it is believed that as much of the report has been presented to our engineering readers as will prove of use to them for the purpose of reference.

A Tunnel under Boston Bay.—An exchange tells us that a tunnel is projected to connect East Boston with Boston. The expense is estimated at $2,000,000, while the ferries, which are free now, cost $100,000. The plans have been made with two tubes, each with an inside tube of twenty-one feet, and to accommodate horse cars, teams and pedestrians.

Photometry in Rail Making.—The *American Gas Light Journal* contains a short item which is quite interesting as noting the application of one art to the service of another, where not the slightest relation would have been suspected. It is namely, that in the rolling mills for iron rails in Russia, a form of photometer is in use for the purpose of determining the exact temperature at which the rails must be sawed off, in order that their lengths shall be uniform.

Gun-cotton and Gunpowder.—Our English cotemporaries record some interesting results of experiments conducted at the Royal Arsenal at Woolwich, in order to decide how far Abel's compressed gun-cotton, which has recently been considerably introduced in the military service, is liable to explode in bulk, by simple ignition; and also whether or not the explosion or ignition of one case of gun-cotton would cause the explosion or ignition of neighboring cases.

The only experiment we have space to record is that which follows: A quantity of compressed gun-cotton was packed in wooden cases, containing 28 pounds each, which, as regards explosive power, is equivalent to about 112 pounds of gunpowder. In the first instance, one of these 28 pound cases, the lid of which was tightly screwed down, was ignited. There was a sudden burst of bright flame, which opened the box without destroying it, and without causing anything of the nature of an explosion. After this, eight cases, each containing 28 pounds of gun-cotton, and two cases containing each 28 pounds of damp gun-cotton, were placed on the ground, and covered and surrounded by thirty-two more boxes, each of which contained a quantity of sand equal in weight to 28 pounds of gun-cotton. The object was to imitate as nearly as possible the condition of things in a magazine of gun-cotton, where a number of cases would be piled together, and one of them might be accidentally fired. The ignition of one box caused a sudden rush of bright flame, which penetrated through the pile, and was followed by another rush of flame, due to the ignition of the contents of another box—without any explosion. The result on examination proved to be only a partial disturbance of the pile on one side and the ignition of the contents of only one box in addition to the box full of gun-cotton purposely ignited. The gun-cotton in the six remaining cases had not been ignited, nor had the damp gun-cotton. If any one will take the trouble to consider what would have been the effect of exploding a barrel of gunpowder in the midst of seven other barrels of gunpowder, closely packed and built up into a pile with other barrels, he will be able to appreciate the exceptional and very satisfactory behavior of the gun-cotton in this experiment.

The new Caisson of the East River Bridge.—To prevent and extinguish fire, which under the high pressure of air almost proved destructive to the former caisson, the new one has been pro-

vided with a lining of boiler iron. A [illegible] of pipes is distributed through the structure in such a way that a large stream of water can be readily turned on.

A new danger to Ocean Cables. A recent announcement of the Superintendent of the International Telegraph Company between Punta Rosa and Key West, according to a notice in the *Iron Age*, has placed a new item upon the list of dangers to which ocean cables may be subjected; and against which suitable provision will have to be made.

The cable in question had, during the past year, been so frequently injured or broken, that a careful examination was decided upon, the result of which was to the effect that the damage was to be ascribed to the loggerhead turtles, which are abundant in those waters. In many places the cable presented the appearance of having been bitten through; and in others of having been crushed from both sides, until it had become so much flattened as to destroy its conductivity. The conclusion of Col. Heiss, the superintendent, is further confirmed by the fact that at the depths where the breaks and injuries occur, there the loggerheads most abound. Our contemporary remarks, in conclusion, of this unforeseen source of danger, that the International Company, whose line has been so badly chewed up by the turtles, have sent an order to New York for a much larger and stronger cable, and when it is laid the assailants will have something more substantial than the present steel-wound cable upon which to whet their teeth.

The Census Enumeration of 1870.—From the recent tables issued by the Census Bureau at Washington, it appears that the total population of the United States is 38,538,180, showing an increase within the last decade of 7,094,859. In relation to population, a comparison of the condition of the various sections of the country with the enumeration of 1860, furnishes some instructive facts. The New England States are about at a stand-still, New Hampshire and Maine even showing a small decrease. The Middle and Southern States are slowly increasing, while the great increment has added itself to the Western States and Territories. The following tabulation will show the totals for both enumerations:

	1870.	1860.	Gain pr. ct.
Total of Territories,	422,500	259,577	
" " States,	38,059,680	31,183,744	21·1
" " United States,	38,538,180	31,443,321	22·6

The Mass of the Moon determined from observation of Tides, by Wm. Ferrel.—At the meeting of the National Academy of Sciences, on the 19th of April, 1871, Mr. Wm. Ferrel, of the United States Coast Survey, gave an account of his discussion of tidal observation with reference to determining the mass of the moon. He used in this investigation a series of observations made for the Coast Survey during nineteen years—a full lunar cycle, at Boston, Mass., and a similar series of observations made at Brest, France, from 1812 to 1831, inclusive.

Without going into the mathematical form of the investigation it will be readily seen that the moon's mass must be mainly inferred from the ratio which the spring and neap tides bear to the constant or average tides. This ratio, however, does not depend entirely upon the moon's mass, but varies greatly for different ports, the heights and times of the tide being modified by local circumstances, and consequently the tides have not been hitherto considered an available means for determining the mass of the moon.

In addition to the constant to be determined by observation, introduced into the conditions by Laplace for determining the moon's mass, Mr. Ferrel has introduced another depending upon friction. Hence, there being three unknown quantities to be determined, including the moon's mass, he uses the condition depending upon the moon's parallax in addition to the two used by Laplace. Without the introduction of this additional constant and the additional condition for eliminating it, Laplace's conditions for the determination of the moon's mass entirely fail when applied to the Boston tides.

Laplace selected Brest, where the tide has a direct and short approach from deep water, and neglecting the effect of friction referred to, obtained, as is well known, the value, $\frac{1}{74{\cdot}96}$ in terms of the earth's mass for the mass of the moon. At Brest the ratio of the half-monthly inequality to the co-efficient or half-range of the constant tide is about ·358, that of the constant tide being about 2·25 metres, and that of the mean spring tides being about 3·05 metres. At Boston the same ratio is only about ·14, the coefficient of the constant tide being 4·91 feet, and that of the mean spring tide 5·58 feet. From data so widely different, Mr. Ferrel has deduced, by means of the introduction of the term depending upon friction, two values exhibiting a remarkable agreement, viz., from the Brest tides, $\frac{1}{77{\cdot}14}$; and from those at Boston, $\frac{1}{78{\cdot}64}$

The former value has the greater probability, as a small variation in the observed height has a much less effect upon the inferred value of the moon's mass at Brest than at Boston. The most probable value that can be inferred from Mr. Ferrel's discussion may be taken as $\frac{1}{77 \cdot 5}$

For comparison, the determinations by other methods may be quoted. From the observed co efficients of the principal term of lunar nutation by different astronomers, we have the corresponding masses of the moon :

	Co-efficient of nutation.	Mass
Brinkley, . . .	9·25	$\frac{1}{71 \cdot 3}$
Peters, . . .	9·222	$\frac{1}{81 \cdot 1}$

From the following observations from determinations of the lunar co efficients in the solar tables, we have the corresponding masses of the moon, assuming the solar parallax equal to 8″·85.

	Co-efficient.	Mass.
Burckhardt, . .	6·80	$\frac{1}{77 \cdot 4}$
Airy, . . .	6·46	$\frac{1}{81 \cdot 5}$

The Misuse of a Symbol.—Captain William Noble has communicated a note upon this subject to the Royal Astronomical Society,* in which he very properly records his protest against the very common misapplication of the mark ″.

The legitimate signification of this symbol is, as no one will dispute, seconds of *arc*, but in numberless papers in our different scientific journals, it is used indiscriminately to designate, not only its proper term, but seconds of *time* and *inches* as well. That this misuse of the mark in question may readily originate ambiguity will appear from the following extracts, which we are sure any of our readers can duplicate *ad libatum*:—A certain observatory is stated to be 24″ E. of Greenwich, while as a matter of fact it is 24 seconds of *time* east of that meridian, and not 1·6 seconds, as would follow from the true meaning of the symbol. It is very common to speak of a 4″ lens, meaning, of course, a lens having a focal length of 4 inches. In the present ambiguous application of the symbol, it would be safe to assert that the lens in question subtended an angle of 4 seconds of arc, and that the observatory referred to, was 24 inches east of Greenwich.

* See their Notices, Vol. XXXI. p. 134.

The proper terms expressing the examples instanced, it is hardly necessary to add, are $''$ for seconds of arc, sec. for seconds of time, and in. for inches.

Employment of the Spectroscope to determine the quantities of substances.—The use of the spectroscope to detect minute traces of substances has been the most glorious achievement of the chemistry of the last decade; perhaps its employment to determine minute quantities may be the great exploit of the next. As an essay in this direction, may be noticed the interesting contrivance of K. Vierordt,* who divides the movable plate of the slit of the spectroscope into an upper and lower half. Each half is provided with a micrometer screw, by which the width of the corresponding slit can be accurately measured. If the upper and lower slit are of the same width, the two spectra are of equal strength. If, however, a transparent colored medium be brought before the upper slit, for example, a tinted glass, a thin plate of any colored body, or a solution of a colored substance in a tank with parallel sides, we have two spectra of different intensities. The other slit is now diminished by the motion of the micrometer screw until the spectra are made equal in strength, and by comparison the amount of this motion is made to give the amount of coloring matter present. A. R. L.

Solvent for Indigo.—The extensive employment of indigo makes it important to notice some new solvents which V. Wartha† has recently found for it. In the first place, Venetian turpentine, heated to the point of ebullition, dissolves indigo with the same blue color as does sulphuric acid or aniline. After cooling, magnificent copper-red crystals separate. The crystals can easily be freed from the solvent by ether or alcohol. Boiling paraffine is an equally good solvent. A somewhat dilute solution of indigo in paraffine can with difficulty be distinguished from alcoholic solution of fuchsine. After cooling, the separated needles can be cleaned with benzol, etc. Petroleum dissolves indigo with carmine red solution; so also spermaceti and stearic acid, the first with carmine violet, the last with blue color. A. R. L.

Itacolumite.—A specimen of this rock has lately come to our hands from North Carolina, which seems worthy of notice from its extreme flexibility. The specimen in question is a very com-

* Ber. der deutsch. chem. Gesell. IV., No. 6, p. 327.

† Ber. der deutsch. Chem. Gesell. IV. No. 6.

pact, fine grained variety, in which the lamination can only be detected with difficulty. The dimensions are: length, 7 inches; width, 2 inches; thickness, $\frac{1}{4}$ inch. The amount and variety of its motions are quite surprising. Not only may it be bent in the plane at right angles to that of its lamination, but in the plane of lamination also; and if a torsional strain is applied to the ends, the rod obeys the pressure quite perceptibly.

The Reversal of the Sodium Line.—The ordinary method of reversing the sodium line, namely, that in which some weakly luminous sodium vapor is brought between a white-hot body and the slit of the spectroscope, demands that the white light shall possess considerable brilliancy, in order that the sodium vapor shall absorb a much greater quantity of light than it emits, and the sodium line thus possess a feebler luminosity than the neighboring portions of the spectrum.

It is to be expected that this reversal will take place far more readily if, by any means, the brilliancy of those portions of the spectrum in the neighborhood of the D line can be increased to the same extent as the brilliancy of the sodium line is increased by the luminosity of the sodium vapor.

According to A. Weinhold,* this condition of things can be brought about in the following simple manner: Place before the slit of a small spectroscope (consisting only of the pierced tube without lens, and a prism of good dispersive power) a small petroleum lamp; then bring an alcohol flame strongly charged with salt, in such a manner between the prism and the eye that the whole spectrum shall be covered by it, and then instantly a well defined, dark sodium line makes its appearance: while the same alcohol flame, if placed between the petroleum lamp and the slit, produces a bright line.

Artificial Coloring of Wines.—The methods in general use for the detection of the artificial treatment of wines, to counterfeit those of better quality, are so universally unreliable that the mention of a recent method proposed by T. L. Phipson,† which seems worthy of recommendation, may prove of interest. The chemist in question proposes to examine the wine spectroscopically. It is declared that the natural coloring matters of wines produce no definite absorption bands, but only a very general absorption of the spec-

* *Pogg. Ann.*, CXLII., 321.

† *Chem. News*, XX, 229.

trum, which is greatest towards the violet end of the spectrum; while, on the contrary, the coloring matter of Brazil-wood, &c., generally used in this counterfeiting process, produce very decided and easily recognizable absorption bands. The method of testing which he recommends is to add water, if the wine is too dark, until it is sufficiently transparent, and then to examine it; and states that every wine is to be regarded as suspicious in which the least sign of an absorption-band appears.

A. Facceu* has given another method with the same object in view, which consists in treating the wine with an equal weight of coarsely-powdered black oxide of manganese, and stirring the mixture for about $\frac{1}{4}$th hour. It is asserted that wines with natural coloring matters will be completely discolored, while those which are artificially colored always remain more or less colored after filtration. It is, however, to be mentioned, that the efficiency of this latter method has been denied. The first may prove of great value.

The Nitro-Chromic Battery Fluid.—Its practical working.—The accompanying letter in relation to this subject may prove of interest:

Office Superintendent Fire Alarm Telegraph,
New York, August 11th, 1870.

W. Goold Levison, Esq.: *Dear Sir*—You will probably remember that in the latter part of June or early part of July, 1869, you described to me a battery you were then experimenting upon, which seemed to me to be part Grove and part Electropoion. Since that time I have been so very busy that the matter passed from my mind.

It gives me pleasure to say that since our late conversation, which revived clearly your former explanation, I have tested the battery, and, following your directions strictly, have, to my surprise, developed an indestructible LOCAL battery.

On the first day of the present month I put up your battery, viz., filled up the porous cup around the coke with bichromate of potash, filling up with nitric acid, then in the glass jar, a solution of sulphuric acid 1 to 10. At the same time I put up the same number of cups (five) of the electropoion battery.

Testing each battery through galvanometer with 38 miles of resistance, I found that each marked 40°. I then placed 3 cups of your battery in service (working two machines), and 2 cups short

* *Fresenius Zeitsch*, IX, 121.

circuited, with six inches of wire. These remained so for 20 [illegible] after which the 3 cups showed 28° and the 2 cups 10° [illegible] *resistance*. I then for the same length of time, placed the electropoion battery, 3 cups in service and 2 short circuited, and my tests then showed the elec. 3 cups to be 23° and the two cups DEAD. The new battery, on being tested at this time, showed 3 cups *thirty* degrees, 2 cups FIFTEEN degrees.

I have this afternoon found the 5 cups electropoion DEAD, while the *new* battery is in such good condition that I have put the 3 cups in service again, and the 2 cups on short circuit. That the tests should be as perfect as possible, I directed that neither should be renewed or aided in any manner. When I shall have succeeded in killing the two cups, I will send you word. To my further surprise, the *new* battery shows the cokes, for full two inches below the clamp connection, to be perfectly dry, and not a sign of formation of chrome alum, while in the electropoion battery the cokes became saturated before the first test was made, and now have a large deposit of chrome alum on the clamp connections.

I propose to make some very close and severe tests, the result of which I will communicate.

It affords me great pleasure to lay before you the foregoing facts, and also to congratulate you upon the discovery of a *local battery*, which, for its great endurance, steadiness of action and economy, must soon be universally adopted. I am very truly yours,

CHARLES L. CHAPIN,
Sup't F. A. Telegraph.

Solid Bi-Sulphide of Carbon.—A curious process of bringing about the congelation of a number of volatile compounds, and which appears to have the fortune of being periodically re-discovered and announced, is that of blowing upon them a jet of air. Treated in this way, bi-sulphide of carbon, chloroform, iodide of ethyl, and other volatile liquids, may be rapidly evaporated, but where the blast of air parts the surface, a floculent, snow-like solid makes its appearance, and finally remains behind in the vessel.

The temperature during the process of evaporation sinks very rapidly, the bulb of the thermometer coating itself with the solidified substances, and a cold of —10° to —12° C. can be readily produced. The solid thus obtained slowly liquifies, retaining all the while a temperature much below the freezing point of water.

The nature of the body thus obtained is a question still in dis-

pute. Taking the bi-sulphide of carbon as the example, it is found that the solid obtained from its evaporation in the air always contains a quantity of water, this quantity is, however, not a constant one, but varies from 5 to 30 per cent. The questions in dispute are now: is the solid obtained essentially frozen bi-sulphide of carbon, in which some condensed and frozen water is mechanically suspended; is it a solid hydrate of the bi-sulphide; or, lastly, is the solid simply frozen water in which is suspended minutely divided particles of the liquid bi-sulphide, which by rapid evaporation cause the low temperature?

The question is not one so easily decided; seeing that solid bi-sulphide of carbon can readily be produced free from water with the aid of the air-pump. Some of the objections, too, which are urged against the proposition to term the substance solid bi-sulphide, may be urged with equal propriety against the solid carbonic acid, which is formed, as is well known, by allowing the gas liquified under powerful pressure to stream through the air into an appropriate reservoir. The solid carbonic acid is formed under very similar conditions to those in the experiment we are considering, and always contains a variable per centage of water. Yet no one has doubted the existence of the solid carbonic acid because of the frozen water it contained. An assertion of a positive character would hardly be justifiable while the matter is still under investigation; but from all that has thus far been advanced, it would appear that the weight of evidence is in favor of the view, that the product obtained by the air blast is really solid bi-sulphide, chloroform, &c., in which is mechanically suspended a variable quantity of frozen water. In conclusion, it may be remarked that in a few experiments which we have performed in this direction with ether, although a temperature of —8° C. was obtained, not the slightest appearance of solidification was observed, but liquid could easily be brought to the consistency of syrup.

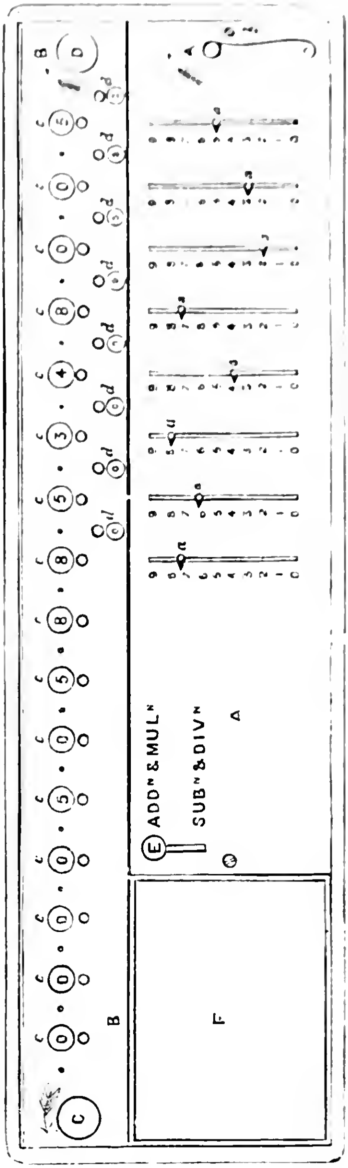
The Arithmometer.—Some of our readers may perhaps already have heard of this calculating machine, the invention of the late Monsieur Thomas de Colmar. A few remarks, therefore, on its construction and operation may be of interest.

The instrument is of small size, the one which we are about to describe being only 22 inches long, $6\frac{1}{2}$ inches wide, and $3\frac{1}{2}$ inches deep.

With its aid eight figures (tens of millions) can be multiplied by

eight figures in eighteen seconds, sixteen figures be divided by eight figures in twenty seconds, and a square root of sixteen figures be extracted, with the proof, in less than two minutes.

The instrument is much used in England and Europe generally, in government offices, in observations, in most of the life insurance offices, and in those of civil engineers and others.



Our illustration shows a top view of an Arithmometer, the lid of the box being removed. It is constructed chiefly of a brass plate A, furnished with eight slots, as shown; directly under these slots are mounted eight drums, each having nine elongated cog teeth of successively decreasing length; over each drum, and between it and the slot, is mounted a square shaft, on which slides a pinion-wheel, so as to catch any number of teeth on the drum. Each of these pinion-wheels is moved by a button *a*, of which there is one in each slot, the figures at the sides of the slots showing the proper position of each button *a*, for any work to be performed by the instrument. The cogged drums gear by bevel-wheels with a long horizontal shaft, which is also in gear with the vertical shaft moved by the handle *b*, by which the instrument is worked. B is a moveable brass plate, which can turn and slide on a round bar hinge at the back; in this plate there are 16 holes *c*, under each of which is a moveable disc, numbered from 0 to 9, and arranged so that any one figure of each disc may be brought

under its corresponding hole, *c*. These discs have bevel-wheels which gear with bevel-wheels on the before mentioned square shafts. The moveable plate B is also furnished with the holes *d*, having disks numbered from 0 to 9 underneath, and are for showing the number of turns of the handle, giving by this means the quotient in division and showing the multiplier in multiplication. The knobs C and D are for bringing the figures under the holes *c* and *d* to zero before commencing an operation, and the knob E is for setting the instrument to work addition and multiplication, or subtraction and division; F is a small slate for memoranda.

Before further describing the working of the machine, we would remark that if the knob E be placed at addition, each turn of the handle will carry the figures marked by the buttons *a* under the indicator holes *c*, while if the knob be placed at subtraction, it will subtract from the figures under the holes *c* the number marked by the buttons *a*.

We will now proceed to give an example of the operation of multiplications, the operations for addition and subtraction being sufficiently explained in the previous paragraph.

Thus to multiply 76,847,235 by 6583: Mark the multiplicand on the plate A by the buttons *a*, as shown in the illustration; set the knob E at addition and multiplication, then turn the handle *b* three times for the unit figure of the multiplier, and three times the multiplicand, viz: 230541705, will appear under the holes *c* in the movable plate B; this plate must now be raised and moved one figure or station to the right, and the handle turned eight times for the second figure of the multiplier, and 6378320505 will appear the holes *c;* move the plate B again to the right, and turn the handle five times for the third figure of the multiplier, and 44801938005 will be brought under the holes *c*, and finally by moving the plate B once more to the right and turning the handle six times for the last figure of the multiplier, the total product, 505885348005, will appear under the holes *c*, and the figures of the multiplier, viz: 6583, will appear in the holes *d*.

For division the operation is as simple as for multiplication, and is performed as follows: Thus to divide 414591904 by 4768, set up the dividend on the plate B and the divisor on the plate A, commencing with the unit figure in each case to the right hand; place the knob E at subtraction and division, and move the plate B to the right until the second figure (from the left) of the dividend is over

the first figure (1) of the divisor turn the handle eight times, and an 8 will appear in one of the holes *d*, and will give the first figure of the quotient, while the dividend will now show 5516901, having been reduced by eight times the divisor, as in ordinary arithmetic; move the plate B one place to the left, and turn the handle six times for the second figure of the quotient, and the dividend will be further reduced by six times the divisor, and will mark 1543901; again move the plate and turn the handle nine times, and after moving the plate B and turning the handle five times and three times respectively, the holes *c* will all show noughts, and the quotient holes *d* will show 86953, which is the quotient required; if there had been any remainder it would have appeared in the holes *c*.

Although by the ordinary limits of the machine, a product of 16 places of figures and a quotient of 9 figures only can be obtained, yet by intermediate record by the operator, these limits may be virtually doubled for multiplication, while for division, provided the divisor does not exceed eight places of figures, the dividend and the quotient may be unlimited.

We have not space to enter more fully into the further applications of the instrument, but believe that Mr. W. A. Gilbee, of 4 South street, Finsbury, London, is the sole agent for England and America, and from whom, therefore, any explanations could be obtained.

The Bancker Collection.—For many years past there has existed in Philadelphia, and known only to those of its citizens more especially interested in scientific pursuits, a collection of philosophical and chemical apparatus unequaled in this country, and, if the opinion of foreign savans be taken, without a rival in the world. It was made and owned by the late well-known Charles N. Bancker, Esq., who devoted all the leisure hours of a life extended far beyond the average lot of man, and constantly applied to the successful prosecution of business, to the cultivation of scientific knowledge. For more than half a century he imported from the workshops of Europe their choicest productions in the way of apparatus, and his interest was not limited to one, but extended to all the sciences embraced within the scope of philosophic inquiry.

In this collection will be found cabinets of minerals, with beautifully executed models in glass and wood, to exhibit the immense variety of crystalline forms; charts and maps in relief, with suits rocks to illustrate the geology of various countries; telescopes and

instruments for observing the star, with orreries and globes for studying the motions of the heavenly bodies; models of pumps, rams, jets, mills, and all manner of contrivances to demonstrate the properties of fluids when in rest and in motion. The collection also contains magnets simple and compound, with machines of the most varied description, to illustrate the phenomena of electricity and magnetism. But above all, it is rich in optical and acoustic apparatus. The Abbé Moigno, a distinguished French savant, wrote of it some years ago in *Cosmos*, that "this collection of optical instruments is certainly the most extensive and most brilliant that exists in the world. It embraces in itself more riches than all our cabinets of France, and perhaps of Europe, united. And its venerable founder, whose zeal seems to grow with his age, does not cease to gather the freshest novelties.

"We exaggerate nothing when we estimate the optical treasure of Mr. Bancker at many hundred thousand francs. Besides illustrating the history of optical discovery and research during the present century, it contains numbers of the most valuable and efficient instruments, such as the saccharimeter of Dubosq, the polarizing apparatus of Dove, Powel and Soleil, microscopes by Zentmayer, Smith and Beck, &c., and complete sets of apparatus and objects for repeating the researches of Becquerel and Stokes on phosphoresence and fluoresence. Professor Henry, President of the Smithsonian Institution at Washington, says in a recent letter:—'I am free to say that with the addition of a very few articles that have been improved or invented within the last few years, it would be the most complete series of instruments that I know of for the illustration of the phenomena and history of physics.

"To break up the collection and dispose of it piece-meal, would be a matter of much regret, since the value of the instruments is enhanced by the fact of their being part of a series well adapted to the illustration of the order of the development of science."

Fortunately for the interests of science, the wish of Prof. Henry has been, to a great extent, realized. The entire collection of optical and acoustic apparatus has been purchased by Professor Morton on behalf of the Stevens Institute of Technology, at Hoboken, and is now thrown open to all the students who may wish to prosecute investigation and researches within the walls of that great institution

Civil and Mechanical Engineering.

ON THE USE OF PULVERIZED FUEL.*

By Lieut. C. E. Dutton, U. S. Ordnance Corps.

HAVING been invited by Messrs. Whelpley & Storer, of Boston, to visit their establishment, and examine their new method of applying fuel to metallurgical and other purposes, I have been so profoundly impressed with the results of the experiments witnessed that I take the liberty to lay before the society a discussion of the subject. Their method consists in pulverizing the coal to an extreme degree of fineness, and blowing it into the combustion chamber, where it is ignited and burned in the air which floats it.

The generic idea involved in this process is not new, for it has, during the last forty years, been made the subject of numerous patents in England,† and possibly elsewhere. But to most practical minds it will certainly appear to be new, and will at first receive the hasty judgment passed upon new ideas. Yet nothing can be more certain than that the principles upon which are based the claims of superior economy and efficiency in this mode of utilizing fuel, are entirely sound, and are demonstrable by well known laws of thermodynamics, and by practical considerations familiar to every educated engineer. Although known to some of the highest class of engineers, and considered by them as "theoretically" sound,

* A paper read before the Franklin Institute, at its stated meeting April, 1871. Being an examination of the method of applying pulverised fuel to furnaces and boilers invented by Messrs. Whelpley & Storer.

† In the year 1831, one J. S. Dawes took out an English patent for applying pulverized fuel to the blast furnace through the tuyeres. It proved unsuccessful, owing doubtless to the fact that the agency of fuel in the blast furnace is chemical as well as physical. In 1846 a patent was taken out by one Desboissiers, for pulverizing fuel, and blowing the dust into the furnace, but though the conception involved some correct ideas, the machinery was totally impracticable.

In 1854, Mouchel suggested the injection of powdered fuel and ores, either separately or together, upon a hearth, or inclined plane of a cast-iron box, heated by waste heat from other furnaces.

Mushet proposed, in 1856, to use pulverized coal, carried by the blast into a reverberatory furnace, to prevent the oxydation of the iron. Other intermediate inventions have been patented in England, but no progress made, owing to the difficulty of pulverizing.

yet it has received particular attention in but few cases, owing to the want of practical means of carrying it into effect. The invention of Messrs. Whelpley & Storer has overcome this practical difficulty in a manner so surprising and complete that it seems well worthy of being ranked in importance and value with the discoveries of Bessemer and Siemens. The defect which has hitherto rendered this valuable idea a practical nullity has been the want of a contrivance for pulverizing coal with uniformity and cheapness. It needs but a moment's reflection to be satisfied that crushing by stamps, or by rolls, and grinding with stones, would cost far more than the best results we could hope to gain—let alone the difficulty of transvecting the dust from the pulverizer to the furnace—a matter no less important than pulverizing itself. Let us see how the invention in question annihilates these difficulties.

Conceive an ordinary blowing fan with the following modifications. The box is about 18 inches diameter, and about the same length. Instead of opening at both ends, one end is tight around the journal. The box is divided into two chambers by a diaphragm, so that, really, we have two fans on the same shaft, and their boxes communicate by a hole in the diaphragm around the shaft. The fan at the closed end of the box is, in form and function, a blowing fan. The outer fan is the pulverizer. The coal is fed into the open end of the pulverizing chamber, is caught by the swiftly revolving paddles, and reduced to powder, and is then sucked by the fan through the diaphragm, whence it is expelled by the ordinary tangential pipe along with the blast. The coal is fed in the form of coarse gravel; it is delivered as fine as flour.

The mere statement of the facts in the case at first appears singular. Had any person, who never saw or heard of this contrivance before, been asked to give his opinion as to what could be the result of feeding coal into such an apparatus, he surely would not have predicted the results actually obtained. It would have been quite natural to expect a little splintering of the coal, and the speedy clogging of the pulverizing chamber, or perhaps the destruction of the whole machine in its efforts to clear itself of its contents. But as the truth is quite otherwise, we may well ask by what kind of action is the coal reduced to powder? It is not ground, for the machine is expressly constructed to avoid a grinding action, the paddles being in no case nearer to the walls of the cylindrical shell than half an inch; nor does the coal seem to be comminuted alto-

gether by splintering against the iron surfaces, for although such action undoubtedly takes place at first impact, yet when it has reached a certain stage, and that by no means near the ultimate one, it cannot seemingly continue to any material extent. The only explanation occurring here, and that not at all satisfactory, is, that in the powerful commotion produced by the swift rotation of the paddles, the particles clash fiercely together and triturate each other a view confirmed in some measure by the appearance of the dust under the microscope. But whatever the mode, it is certain that the coal is pulverized to an extreme degree. I have watched this machine for hours, and have caused it to be fed under my own eye, and the products collected in a bag, of which I submit a sample. As nearly as I can estimate by microscopic measurement, fully nineteen-twentieths of the particles are less than $\frac{1}{500}$ of an inch in diameter, and none exceed $\frac{1}{150}$ of an inch. From the open end of the pipe it floats away in a dense cloud of smoke, and, singularly enough, not a black smoke, but of a reddish brown color, differing strikingly from the jet black of coal. This may, or may not, indicate extreme minuteness of subdivision: I offer no explanation of it. The still more astonishing performance of this machine in rereducing quartz, ores, grain, &c., will be alluded to hereafter.

The function performed by this machine is a double one. It pulverizes the fuel and delivers it, along with the blast, into the combustion chamber, by a single and indivisible operation. This combination of two acts into one is of vital importance, and may be said to constitute the central idea of the mechanical part of the process. It would otherwise be useless for metallurgical or even for calorific purposes. It removes at a single *coup* the two most formidable obstacles which have hitherto rendered the use of pulverized fuel impracticable. Another feature of high importance is the mechanism for regulating the supply of air and coal. The inventors have devised an excellent apparatus for this purpose, which controls both with precision; but as this is merely a matter of mechanical detail, I presume it will be taken on trust, and a description of it is omitted. I shall confine myself to a description of the functions performed by it, which are greater than would at first appear. The pulverizer seems to be governed by very definite laws, and a precise practice, in the amount of work it can perform with economy. A machine, working upon a given fuel, will have its efficiency modified by three variable conditions:

1st. The velocity of the shaft.

2d. The quantity of coal introduced.

3d. The quantity of air introduced.

1. With regard to the first condition, practice has shown that there is a uniform, or nearly uniform, velocity suitable to every machine, which may be set down at about 10,000 feet per minute for a point on the periphery of the paddles, which, for an 18-inch pulverizer, would be about 2100 or 2200 revolutions per minute. If the speed be diminished, then the coal will be less thoroughly pulverized, and will burn imperfectly and wastefully in the furnace. If the speed be increased, the fineness of the dust will also be increased, but the power required to attain a higher velocity increases in a very large ratio, and the increased fineness of the product is not sufficiently advantageous to compensate the cost of increased speed.

2. The feed of fuel will of course be determined primarily by the requirments of the furnace, and the minimum quantity which will effect the desired temperature will, in each case, be determined experimentally. If the fuel be diminished, an insufficient heat will be obtained, and if it be increased, the loss will be three fold: (1) the surplus fuel will burn to waste; (2) the effort of the machine to clear itself from an overwhelming supply will absorb more power; and (3) drive out the coal before it is sufficiently pulverized—in brief, the result being, more power and more fuel consumed, and less heat developed.

3. The amount of air admitted should be sufficient to float readily the pulverulent coal, but not more. If excessive, the increased draft through the pulverizing chamber will float out much larger particles than can burn efficiently. Generally speaking, it is advisable to keep the supply of air quite small. In any event it will be necessary to supply air for combustion by a separate air pipe, because, if a sufficient quantity were passed through the machine, it would carry out the fuel insufficiently reduced, and moreover, in special applications it becomes necessary to use hot-blast, which would necessarily enter the furnace through a separate pipe—the air from the pulveriser being always cold. Air enters the pulverizer through the same inlet, and along with the coal. The aperture is adjustable, as is also the feeding apparatus, thus affording perfect and instantaneous control over the supply of both. The advantage of being able to stop a fire completely in an instant, and renew it in full force as quickly, and also to regulate it at pleasure, by the

mere motion of a valve, or hand lever, is so great as to need the merest mention in order to be appreciated.

The pulverizer has been applied by its inventors to a variety of purposes, of which I shall discuss two, which seem to afford the widest range for possible advantages, viz: its application to the reverberatory furnace, and to the steam boiler.

1. *Pulverized fuel in the reverberatory furnace.*—This application does not involve a radical change in the structure and design of the furnace; the chief alteration being the omission of the fire place in its present form. Instead of constituting a large proportion of the entire structure, and of prime importance, it is reduced greatly in size, and performs subsidiary functions. It is employed, at first, to raise the temperature of the walls to redness around the coal tuyere, which is necessary in order to ignite the dust as it enters the furnace. Subsequently it is kept closed as tightly as possible, and the fuel within it serves merely to deoxydize the air, which filters through the doors, and to supply a small quantity of carbonic oxide. This small supply of inflammable gas materially assists and insures the speedy ignition of the coal dust.* The gas generator is supplied with anthracite culm, of which it consumes only about 30 pounds per hour. The pulverizer is located a few feet behind the gas generator, and the coal tuyere enters the back wall of the furnace, pointing directly over the fire bridge. The air tuyere is located just above the coal tuyere. The furnace, therefore, is reduced to a hearth, with the pulverizing machine in the stead of the old fire-place.

In discussing the comparative theoretical merits of this method, and grate-burning, some preliminary considerations may be proper. It is necessary to be mindful of the fact that the amount of heat, that is to say the number of units of heat, developed by the complete oxydation of a given quantity of fuel, of a particular constitution, is a constant quantity. It matters not under what circumstances oxydation takes place, whether explosively, as in the case of commingled gases, or by that slow combustion which sometimes requires years to accomplish, the gross amount is always the same. But we are dealing chiefly with *temperatures* in the reverberatory

*It will readily appear that the lambent form of a genuine gas flame is better suited to communicate ignition than the scintillations of specks of fuel, where the flame would have to leap from grain to grain, over an intermediate space of cool or half heated air. It renders ignition more prompt and certain.

furnace—a matter in which quantity of heat is only one of several equally essential conditions, any one of which may be so varied as to occasion the widest variations in temperature. Thus, the increment of temperature produced in a body of gas by the accession of a given quantity of heat, will vary inversely as the volume of that gas—also inversely as the specific heat of the gas. Hence it appears that if we increase the volume of gas (or solid either), through which the heat is to be diffused, we diminish the temperature; or if we impart given quantities of heat to given volumes of gases, the temperatures will vary inversely as the specific heats of the gases. These facts are familiar enough to every student of thermodynamics, and are mentioned merely for the sake of continuity in the argument.

2. For the complete combustion of a fuel of a given constitution, a fixed proportion of air is necessary. When the combustion is complete, we have obtained certain gases, having a definite volume, an average specific heat, and a fixed temperature, which is the maximum temperature which that fuel is capable of imparting. This assumes, of course, that no adventitious heat is added. If an excess of air be supplied, then that excess represents a useless volume, through which the total heat must be distributed, with a consequent lowering of the temperature. If air be deficient, then the fuel will be imperfectly burned, becoming carbonic oxide instead of carbonic acid, and yielding much less heat, with about the same volume of gas, and a consequent lower temperature. We approach the maximum temperature in proportion as we approach the exact proportions of air and fuel necessary for perfect combustion. In common grate burning we depart widely from exactitude in these proportions. At one period we have a grate heaped with fresh fuel, giving off half burned, or wholly unburned, gases; at another, half exhausted coals, coated with ash, to which only a portion of the oxygen can obtain access. The draft, on the other hand, is constant, or only occasionally varied. A stream of air, driven through a bed of ignited coals, first oxidizes the lower layers, converting the carbon it touches into carbonic acid. The latter gas, rising through the bed, takes up more carbon, becoming carbonic oxide, which is, in part, re-oxidized again just above the coals, giving rise to flames. Unless there is a large excess of oxygen, there is a probability that some of the combustible elements of the gases will be unconsumed, owing to imperfect intermixture, and a rapid cooling

below the point necessary to insure ignition by the nearly exhausted oxygen. If hydrogen be present in the form of hydrocarbon vapors, it will, by its stronger affinity, appropriate oxygen, to the exclusion of carbon, and even decompose carbon already oxidized, the latter element passing off in minute flakes, which constitute the dense black smoke always abundantly developed where bituminous or hydrocarbon fuels are burned in an insufficient supply of air. In the puddling furnace these circumstances are more or less modified by admitting a draft over the grate, but the loss of fuel is by no means wholly obviated by this means. In practice, it is usual to drive through the grate at least twice the quantity of air theoretically necessary to oxidize the entire mass of fuel. Indeed, two to one is oftener exceeded than fallen short of. The effect upon the temperature is corresponding, as will appear from the following simple estimates. If a pound of bituminous coal were perfectly burned in a volume of air just sufficient to oxidize all of the combustible elements, the result would be as follows: After deducting the latent heat of vaporization, there would be developed about 1300 units of heat. The resulting gases would occupy (if their temperature were reduced to 60°) 146·6 cubic feet, with an average specific heat of ·26. Their temperature would therefore be $T = \frac{13000}{11 \cdot 22 \times \cdot 26} + 60° = 4516°$; provided no heat were lost by radiation. If twice the volume of air were used, then $T = \frac{13000}{22 \cdot 44 \times \cdot 24} + 60 = 2474°$, or a little more than half the temperature under the first supposition. Assuming the air to be fifty per cent. in excess, then $T = \frac{13000}{16 \cdot 83 \times \cdot 25} + 60 = 3150°$.

Now, it needs but to state the conditions under which pulverized fuel is supplied to the furnace to make it very clear that those conditions are extremely favorable to combustion with a greatly reduced supply of air. We have shown good reason why the enormous excess of 100 per cent. is generally necessary in grate burning. But with pulverized fuel the conditions are radically changed. There, every particle of fuel enters the furnace surrounded by, and in contact with, the very oxygen that is to burn it. The fuel and the air are as perfectly intermixed as possible by the powerful agitation of the pulverizing machine, and at the moment of ignition

the former exposes an enormous surface to the action of the latter. The combustion should therefore be rapid, and very nearly complete, and this without the liability to distil a large portion of gases, or to appropriate carbon from other parts of the fuel less exposed to oxidizing action. Perfect intermixture is essential to perfect combustion. When a current of gas and one of air are brought together, it requires time to mingle them perfectly, and if they are ignited at the junction of the jets, some of the gases will escape combination, though the proportions of each may be exact; for the two are carried forward in eddying currents and whirls, which cannot intermingle until some time after they have cooled down below the temperature of ignition. Hence, we have carbonic oxide, free carbon, oxygen, all escaping from flues and stacks without undergoing combination, and representing so much lost fuel, and adding to the superfluous volume of gases besides. But with pulverized fuel the essential condition of intermixture is vastly improved, so that we seem to approach that perfect intermixture obtained by the transfusion of gases, where atom is in juxtaposition to atom, and we are removed from it only sufficiently to avoid the explosive action attending the contact of flame with perfectly mingled gases. More strictly, the condition of pulverized fuel, sustained in air sufficient to burn it, may be represented by a cube of air $\frac{1}{25}$th of an inch on its edge, holding in its centre a particle of coal.

Now, it is not maintained that these conditions are in their nature such as to insure the perfect combustion of the coal with the theoretical minimum of air, for it is possible to detect circumstances which may, in greater or less degree, interfere with such a result. It must be borne in mind that these particles are not atomic by a very wide interval, and hence their combustion must present the phenomena of progressive absorption of a surface of fuel, and a progressive exhaustion of oxygen; and, as is invariably the case under these circumstances, some minute portions, at least, must escape combustion, unless oxygen be in excess. Then, too, some of the particles are of material size, rendering these phenomena all the more decided. But, on the whole, it certainly seems as though the conditions in question were such that coal, pulverized in the manner described, may be perfectly burned in a supply of air not greatly in excess of the theoretical minimum. At any rate, they are far more favorable in this respect than the best possible method

of grate burning, and probably better than any practical existing method of gas burning.

A prolific source of loss exists in the ordinary reverberatory furnace, which is obviated in great part by Messrs. Whelpley & Storer's method, viz: the loss by radiation from the fire place. Of the heat generated, only that portion exerts any useful effect which is carried into the hearth. A very sensible amount is lost, however, before the flames enter the hearth. This amount is variously estimated by different investigators, none of whom place it lower than five or six per cent. This need not seem surprising when it is remembered that the area of the surfaces surrounding the fire-place through which heat may be totally lost, amounts to one-third, at least, of that of the hearth itself. Also, at very high temperature heat is radiated and conducted away with a rapidity much greater than that due to a simple ratio of the interior to the exterior temperature. This loss is doubly serious, from the fact that the temperature of the flame, at its hottest point, is inconveniently near to that required in the bath of metal itself. The pulverized fuel furnace, on the other hand, does away almost entirely with the fire-place, and burns its fuel with nearly explosive rapidity, in the hearth itself, avoiding this loss almost completely.

These results may seem surprising to practical men, and yet they may rest assured that they are in perfect conformity with well established facts and principles in physical science. It is not proposed to obtain any more heat out of the combustion of a quantity of coal, but merely an increased temperature from the same quantity by diminishing the volume of gas through which that heat is distributed. We also burn the fuel more completely, and lose less heat by radiation. With this increased temperature we increase the efficiency and rapidity of all operations requiring the acquisition of temperature, and thus shorten the time during which we are compelled to burn the fuel. Let us therefore apply this deduction of increased temperature to the practical management of the reverberatory furnace.

(To be continued.)

ON A SHIP CHANNEL ACROSS CAPE COD.

By Jos. P. Frizell, C. E.

The project of establishing a water communication across Cape Cod, between Barnstable and Buzzard's Bays, thereby cutting off a long stretch of dangerous navigation on an exposed coast, has been before the public at different times for the past one hundred years. The object of this paper is to discuss an important physical and engineering problem, which, arising under precisely similar conditions in no other important work that I am aware of, naturally identifies itself with this enterprise.* The question is this: Should the proposed channel of communication be open to the free flow of the tides, or should the tides be excluded, and the surface of the canal be maintained at an uniform level by means of locks?

To fully appreciate the importance of this question, we must take a preliminary glance at the probable cost of the two methods. By the elaborate and detailed estimate of Mr. George R. Baldwin, contained in his report to a committee of the Massachusetts Legislature in 1862, the total cost of the enterprise, including the artificial harbor in Barnstable Bay, forming a necessary part of the method, was put down at about ten millions of dollars. For the item of excavation, including dredging and land damages, about one million and a quarter was allowed by the most favorable route. In a free channel, excavation would be the principal item. It would, in the aggregate, be considerably greater than in a closed canal, though considerable aid, in this regard, might be expected from the scouring action of the current, as will appear hereafter. Piers or jetties extending into deep waters would also be necessary at the easterly extremity, and perhaps similar structures, though of less magnitude, at the western. By comparison with similar works, I should judge that one million would cover the cost of these solid structures. The works at the Sulina Mouth of the Danube, to be spoken of hereafter, cost about $380,000. It is not essential to the purpose of this paper to go into any exactness with regard to cost.

* The length of the channel will be about eight miles. The period of high tide occurs later in one bay than in the other, the daily maximum variation in height between the two bays being 6½ feet, and the extreme variation nearly 8 feet. Full reports, with plans and diagrams, may be found in *Mass. Pub. Doc.*, No. 41, 1863.

From what precedes, it is apparent that I am safe in saying that the cost of the enterprise by the first named method is less than half, and probably less than one-third, of its cost by the second.

It appears from the report of Mr. Baldwin, above alluded to, that his instructions were "to plan a canal with locks," which is probably his reason for refraining from any discussion of a free channel. The legislative committee, in framing these instructions, probably acted under the advice of the advisory council or board of consultation, consisting of Gen. Totten, chief of the U. S. Engineer Department, Prof. Bache, chief of the U.S. Coast Survey, and Commander Davis, of the Navy. In the Report of these gentlemen, I find only the following paragraph bearing upon this question: "We have already spoken of the locks required in consequence of the different levels of the sea at the two extremities of the canal. The mean of the daily maximum variations in the elevations of the basins is 6·5 feet, and such a fall in the distance of eight miles must, we need not say, be kept under control." It is but reasonable to suppose that a mode of establishing the proposed communication, promising such a vast diminution in the expense, would have been thought worthy of some discussion by this eminent board. The absence of such discussion appears to me to be explainable upon only one theory, viz., the project of a free channel is unique. No example exists, that I am aware of, involving the exact conditions presented here. To arrive at a reliable opinion of its practicability would have required considerable study and research, which the duties of those gentlemen, then very onerous, on account of the war, did not allow them to undertake. They accordingly recommended dispositions which they felt certain would answer the proposed ends, without regard to cost.

The average maximum difference of level* between the two bays is 6·5 feet, or 0·81 feet per mile, though in rare and exceptional instances it amounts to 7·75 feet, or about 12 inches per mile: this state of things, be it remembered, lasting only for some 30 or 40 minutes at the turning of the tide. The first mentioned declivity

* In the report of Mr. Mitchell to the Superintendent of the U. S. Coast Survey, he says: "The mean of the results is 4·66 feet for maximum height of Back River Harbor" (Buzzard's Bay) "above Barnstable Bay, and 5·79 feet for the reverse relations of these basins. Not to underestimate the difficulties of the work, I take the larger figures from the report of the advisory council."—*Mass. Pub. Doc.* No. 41, 1863.

corresponds, for a canal of the dimensions contemplated in Mr. Baldwin's report, to a velocity of about 4·5 feet per second, the second to a velocity of something over 5 feet per second. In calculating the velocity, I make use of the formula established by Humphreys and Abbot. * Such velocities are by no means unusual in navigable channels. The Mississippi at Carrollton, near New Orleans, has a velocity of 5·96 feet per second, at Columbus 6·96 feet per second, at Vicksburg 6·95 feet per second. Bayou Plaquemine, a stream 300 feet wide and 28 feet deep, has a velocity of 5·2 feet per second near its upper mouth. The Rhine at Byland has a velocity of 3·6 feet per second. The Tiber at Rome 3·41. † Bearing in mind that the higher velocity given for the ship channel would only occur at rare intervals, and the lower only once in 12 hours, lasting but 30 or 40 minutes, while the velocities given for the rivers are permanent for periods of high water, it must be conceded that so far as the velocity of the current is concerned, the difference of level will offer no insurmountable obstacle to the navigation of the channel. The transit of vessels would in the aggregate be facilitated by it as much as hindered. Sailing vessels, in particular, would undoubtedly endeavor to take advantage of the tides in passing through.

A much more important question is this: Would the current engendered by the tides act so injuriously upon the bed of the channel as to endanger its navigability? It must be observed here that the velocity in a running stream is proportional to the square root of the head or fall,‡ or, otherwise stated, the fall is proportional to the square of the velocity. The abrasive power of the current is proportional also to the square of the velocity. It follows, then, that the abrasive power is directly proportional to the fall. In an inquiry of this nature, therefore, we must use the mean fall, which is not more than four feet, or six inches to the mile.‖ We need look

* Report on the Physics and Hydraulics of the Miss. River, p 312.

† *Ibid.* 316.

‡ It is so assumed by the majority of the Hydraulic writers, though most formulæs deviate slightly from this supposition, not enough, however, to affect the truth of my conclusion.

‖ The advisory council say, in continuation of the remark previously quoted from their report: "We might have given here the extreme difference, 8 feet; for it must be observed that this is a case in which *extreme* and not *means* enter into the argument." The extreme head can only enter into the argument here, with reference to structures designed to control the tide, *i. e.* to locks, since such structures must be strong enough to resist the greatest force that they can ever be

for no greater abrasion here than would take place in any alluvial stream of equal cross-section, with a declivity of six inches to the mile. That rapid erosions of the bed and great shifting of material would take place in a channel exposed to such a declivity, there can be no doubt, but, by comparison with the great water courses alluded to above, I do not find any reason to doubt the preservation of a sufficient depth. The Mississippi, at Carrollton, Vicksburg and Columbus, with a velocity of 6 or 7 feet per second, maintains a high water depth of from 88 to 136 feet. The Rhine at Byland, with a velocity of 3·57 feet per second, has a depth of 20 feet. The Neva in Russia with a velocity of 3·23 feet per second has a depth of 50 feet.* The Mississippi, in six days of high water, carries past Carrollton a quantity of solid material equal to the entire excavation of this channel.† How happens it, then, that the channel of the river does not fill up at this point? Because it is as impossible for material to be deposited in a strong current as to be taken up by a weak one. *A strong current and great volume of water are the surest guarantees of a sufficient depth.*

The bayous of the Lower Mississippi are natural water courses, existing under circumstances very similar to those of the proposed channel. Leading from the main channel of the Mississippi into the Gulf, they flow sometimes with a violent, sometimes with a very gentle current, according to the stand of the river. It not unfrequently happens that some of them, when the river is low, and the surface of the Gulf is raised by northerly winds, flow in the opposite direction, discharging salt water into the Mississippi. Yet these channels exhibit a remarkable tendency to preserve and even to increase their depth. Bayou Plaquemine has a maximum depth of 24 to 28 feet, Bayou La Fourche 23 to 27 feet. The latter is an important channel of inland communication, although no attempt, so far as I am aware, has ever been made to improve or maintain

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exposed to. When we come, however, to speak of the aggregate work of abrasion performed by the current, or the aggregate resistance to vessels occasioned by it, it is obviously not the extreme nor the average maximum, but the actual average head, that enters into the argument. This reasoning of the council, when analyzed, is a little curious. The necessity for assuming an extreme head rests upon the supposed necessity for locks. The necessity for locks rests upon the assumption of an extreme head.

* Report on Phys. and Hyd., &c., p. 316.

† *Ibid.*, pp. 148, 150.

its navigability by artificial means. The former, being of short length, and not forming a link in any important route, is not much used for that purpose. Messrs. Humphreys and Abbott* say: "Bayou La Fourche, the last of the outlets of the Mississippi, in many respects resembles an artificial canal. Its current does not exceed three feet per second, its bends are few in number and gentle in curvature. There are no boils, whirls or eddies, nor are the banks abraded to any perceptible extent. * * * Its width between the natural banks averages about 230 feet and undergoes but little variation."

There is a class of artificial channels which bear a still more striking analogy to this work, viz: cut-offs, occurring at great bends of rivers. This channel would simply be a cut-off in tidal waters. Several operations of this kind have been executed upon the Mississippi, in some cases shortening the navigable channel more than twenty miles. The declivity in such streams is sometimes very great, the entire fall in a long channel of the river being concentrated in the short channel of the cut-off. The fall through Raccourci cut-off in the flood of 1851 and also of 1858 was 7 inches per mile.† This is greater than the effective fall (as regards abrasive power) in the C. C. channel, yet these cut-offs are daily traversed by deep laden steamers, and no engineer that I am aware of ever suggested the use of locks at these localities. They sometimes occur spontaneously, and in all cases the erosive power of the current is the chief agent in their formation.

A great number of these works have been executed upon the Rhine.‡ Between Neuberg and the Hessian boundary there are no less than 75 miles of cut-offs, the number being 17. They are usually excavated artificially, deep and wide enough to let in the current in sufficient volume to be effective, and, in the majority of cases, in from one to four years, become navigable for the vessels that frequent the Rhine Stream. Taking the average of all these channels, the fall per mile is greater than the effective fall in the C. C. ship channel.

I have endeavored, thus far, to illustrate the workings of the proposed channel by reference to streams flowing permanently in

* Report on Phys. & Hyd. &c., p. 423.

† Report on Phys. and Hyd., &c., p. 375.

‡ Hagar. Handbuch der Wasserbaukunst, Zweiter Theil. Die Ströme, 2d Vol. p. 115. *et seq.*

one direction. To anticipate all the objections that may be urged against my views, it may be necessary to instance channels whose depth is maintained by tidal currents.

A glance at the chart of the Hudson is instructive in this connection. The river presents a broad and deep channel from the mouth nearly up to Albany, or just so far as the tide is effective in producing strong currents. The point where this influence ceases marks the transition from a broad and deep channel to a shallow, tortuous and difficult one.

The improvements now being executed in the upper portion of this river consist mainly of dispositions intended to increase the current, such as dykes cutting off unnecessary expanses of the water, closure of chutes, &c., the object being to create a greater velocity and force the current to take up a greater amount of sediment. Dredging is resorted to only where the application of this method would be too expensive. One reflection is important here. Is it not to be feared that the material taken up where the current is artificially increased will be deposited in the lower reaches of the stream to the detriment of navigation? No trouble, so far as I can learn, exists or is apprehended from this cause. The material once brought within the range of the strong currents due to the tides, cannot remain permanently deposited in the channels. For the same reason, in a free channel across the Cape no apprehension need be felt that material excavated at one part of the channel will be deposited in another, to the injury of navigation, so long as a general uniformity of cross section is preserved. Material once taken up by the current is held in suspension until the velocity of the current abates, and cannot be permanently deposited except at the outlets where the effluent current is brought to rest.

The East River, between New York city and Long Island, is one of the many instances that might be named of a channel kept open by tidal currents.

(To be continued.)

ON A NEW MACHINE FOR PRODUCING TRUE CYLINDRICAL SURFACES.

By J. Morton Poole.

Late in the year 1866, application was made to the ftrm of which the writer is a member, by Jessup & Moore, of Philadelphia, to construct for them a stack of the rolls used in their business for calendering paper. The stack in question was to be composed of nine rolls, eighty-four inches wide on the face, and varying in diameter from six to fifteen inches. The problem to be solved was to construct this calender with such accuracy that when the nine rolls composing it were placed in position, one above the other, the line of contact between any two adjoining rolls would be so perfect as not to allow light to pass through.

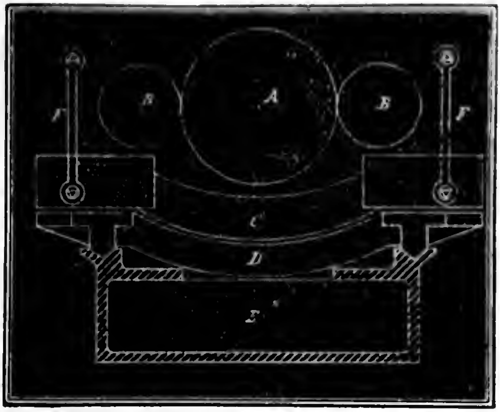
Two approximate ways of effecting this object were in use. The most common was to turn the rolls as true as could be done in a lathe, then to place them in stands similar to those in which they worked when in use, cause the surfaces in contact to run in contrary directions and smear them plentifully with oil and emery, at the same time giving the rolls a slight motion of translation to prevent their wearing in ridges.

The other method was to use a revolving metal lap with emery and oil, verifying the work as it progressed with straight-edge and calipers, setting the rolls in position, marking the high places, grinding and marking again, and so on approximating toward perfection.

Both of these processes produced very unsatisfactory results, and as the writer had in use in his business machinery on a small scale for grinding with an emery wheel, he designed a machine to use this method of grinding, on a scale sufficiently large to grind the large rolls called for in the stack. The drawings were completed and the patterns partly made, when the conviction before felt became more strong with him, that to depend for the accuracy of results upon the accuracy of the ways of a grinding machine, which, however straight they might be at first, would soon lose their truth by the natural wear of one part moving on another, would only result in disappointment. At this juncture there flashed upon his mind the true principle whereby perfection would be obtained without regard to the perfection of the ways of the machine, and

he hastened to destroy his patterns and drawings and to start afresh, the result being the machine we are about to describe.

In the illustration, E represents the bed, which is constructed somewhat like the bed of a planing machine. D is a saddle, which slides in the ways on the bed. Suspended to this saddle and above it, by the links F F, is a second saddle, C, which carries two grinding wheels, B B. These wheels are capable of separate adjustment to grind rolls of different diameters. A represents the roll to be ground. The links supporting the saddle, C,



rest on knife edges, and every effort is made to reduce the friction, so that the least possible force is required to cause the saddle to vibrate. The saddle C is also made exceedingly strong and heavy, both to resist any possible spring and also to have sufficient gravity to resist the pull of the driving belts. An arrangement is provided whereby any amount of friction may be put on the vibration of the saddle, even to the extent of locking it fast and preventing its vibration entirely. Now, it is evident that if the ways on which the saddle D slides were perfectly straight, the axis of the roll A placed perfectly parallel with the line of motion, the saddles C and D locked together, and the machine set in motion, that the cylinder produced by grinding would have the same perfection as the ways on which the rest travels. That this is impracticable we have before shown. It is also an impossibility to set the axis of the roll A perfectly parallel with the line of motion of the rest; there will always be some little want of parallelism, the effect of which would be to make the cylinder a frustum of a cone.

To illustrate the manner in which the accuracy of results obtained is quite independent of the accuracy of the ways, or want of parallelism between ways and axis of roll, we will assume that the ways of our machine are curved, or irregular in form, so that with our saddles locked together, and the roll ground with a single

grinder, the outline of the roll would be an exact copy of the irregularities of the bed. Consider the roll A as having been ground in this way, so that every part revolves truly.

We now relax our friction arrangement, so that the upper saddle is perfectly free to swing transversely.

Now, the effect of this curved or irregular form of the ways would be, as the rest traverses, to force one grinding wheel against the roll and the other away from it, but the saddle C being free to move transversely, yields the moment the pressure of the two grinding wheels on the roll would tend to become unequal, or rather the upper saddle remains stationary, both grinders bearing on the roll with the same force, and allows the lower saddle to move beneath it as it follows the irregularities of the bed. It is evident that these two grinding wheels, once adjusted on their saddle, the distance between them cannot vary; and that if they can be traversed from end to end of a roll without a reduction in their diameter, the roll revolving truly and both grinding wheels bearing on the roll with the same force, that the diameter of the roll must be the exact distance between the circumference of the grinding wheels, and consequently uniform. As all these requirements are fulfilled in the machine just described, it is evident it cannot do otherwise than produce a perfect cylinder, which problem it, for the first time, solves, and solves too in a manner far more expeditious than by any of the imperfect and approximate methods before mentioned. Supplying as it does a want which has been much felt, it has not failed to be appreciated, and in the purpose for which it was originally designed, that of grinding paper makers' calenders, it has nearly superseded any other method.

The heavy chilled rolls used in the rubber manufacture and in that of brass, copper, sheet iron, &c., have also been ground by this principle, and always to the manifest improvement of their products.

The above description serves to give a general idea of the principle upon which this machine depends for the accuracy of its work. There were, of course, many details to work out, and much knowledge to be gained before this principle could be reduced to practice. The first great difficulty was with the grinding wheels themselves, and their perfection cost more time, labor and expense than any other part of the machine. When it is considered that these wheels are required to traverse from end to end of a roll sometimes

as long as eight feet, without perceptible wear or diminution in diameter, it will be seen what a difficult matter it becomes, and yet one that it was necessary to accomplish before the machine was a practical success.

Another point early developed was the impossibility of grinding a cylinder true without it was kept at an uniform temperature by the application of a plentiful stream of water. The attempt was first made to grind dry, but it was found that if the rolls were ground true and allowed to cool, they were as much out of truth as at the beginning of the operation. It was also found that the greatest care was requisite to have the journals on which the roll revolved during the grinding operation, ground till they were truly round. With bearings *not* round, in grinding with a single grinder the outline of the roll will be a copy of the irregularities of the bearing; but with wheels on each side there is a constant strife between them to change the outline of the roll, which renders it quite impossible to grind it to any degree of truth. It will thus be seen that the two wheels act as a check upon the roundness of the bearings, which have consequently to be ground themselves on dead centres till they are perfectly round and true.

The principle of this machine has also been applied to grinding the rolls of curved outline required in the sheet iron manufacture. These are of such a form that when heated by the operation of rolling they are straight. This necessitates their being smaller in the middle, and they are ground by placing the roll in the machine in such a position that in the middle of its length its axis and the axes of the two grinding wheels are in the same straight line, and one end of the roll is elevated a certain distance above the axis of the grinding wheels, and the other end depressed a corresponding distance below. The result is that the curve required is ground with great exactness, and may be varied to any amount of concavity by elevating and depressing the ends of the roll more or less.

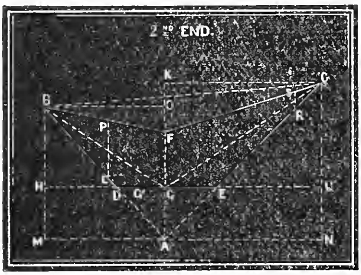
In conclusion, we would say that the principle upon which this grinding machine works being a perfect one, its work can only vary from the truth by reason of mechanical defects or deficiencies. For example, the wear of the grinding wheels in passing across the roll would have the effect of grinding a frustum of a cone. There must be *some* wear—how inappreciably little it must be, and how near perfection are the rolls ground by this process, will be seen when we say that two rolls gently pressed in contact, with an endlong movement given to one, will produce a continuous burnished line on each from end to end, and that the rolls composing a stack may be arranged in the thousands of ways in which a number of rolls may be combined, and they will still coincide and touch each other throughout the whole length.

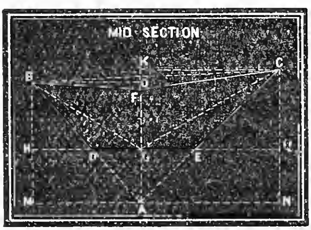
FORMULÆ, RULES AND EXAMPLES OF COMPUTATION FOR SOME OF THE MOST USEFUL CASES OF EARTHWORK UNDER WARPED AND PLANE SURFACES.

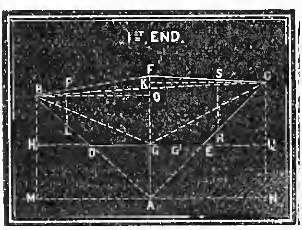
BY JOHN WARNER, A. M.

Object proposed.—I shall here present a number of formulæ which, it is believed, will be found useful in practice and interesting for their form and mode of derivation.

*Definition of the Ground Surface:—Straight Work.**—Intending, on a future occasion, to treat more at length of the ground surface, I shall here only define it as assumed for the present investigation, and omit extended remarks on the practical sufficiency or utility of the formulæ. The ground surface is assumed to consist of one or more hyperbolic paraboloidal surfaces generated by the motion of straight lines always parallel to the vertical end planes of the work, and moving lengthwise of it upon straight directrices. The external straight bounding lines of the surface, which connect the outside corners of the work, are always supposed to be directrices, and the straight surface line connecting the extremities of the centre heights at opposite ends of the work is always taken for a directrix when this line is supposed to exist. Other straight directrices may be imagined to extend from points on the surface line of one of the end cross-sections to points upon the surface line of the other; but in all cases no two directrices must cut the same longitudinal vertical plane within the limits of the work. The two end cross-sections and the mid cross-section of a piece of so-called *three-level* ground may be represented, in their general features, by the annexed diagrams, which refer to excavation but will serve to explain







* The discussion of curved work is here omitted.

embankment by imagining the diagrams inverted. These will be understood without minute explanation. The surface lines F B, F C, on any cross-section of three-level ground are supposed to be straight: these are the generating lines of the ground surface, which move upon straight directrices passing through B B, F F, C C. The line B F C may either be broken in F or be a continuous straight line, according to the relative dimensions of the cross-section under consideration. If B F C is a broken line on any one cross-section, the ground surface will be divided into two portions, one on the right the other on the left of the centre; either or both of which portions may be warped or plane. In like manner each of these portions of the surface may be again subdivided, and so on, as long as the inequalities of the surface lines of the end cross-sections require this mode of subdivision. If the lines F B, F C, form a continuous straight line on each of the end cross-sections, the ground surface if not plane may, according to the judgment of the computer, be considered either as a single warped surface having everywhere the straight surface line B C, or the surface line B C may be considered as broken at F on all cross-sections except those of the ends. When the surface is a plane, both these hypotheses merge into one.

Of the other Bounding Surfaces.—These are generally plane in practice. The present paper treats the roadbed and the end surfaces as necessarily plane; the side slopes are not always considered necessarily plane, nor their inclinations necessarily equal.

Given Dimensions include the length of the work, the centre and side heights, distances, width of roadbed, and angles of side slope; but all these are not necessary in every case.

Notation.—It will perhaps be more convenient to exhibit this collectively than scattered through the paper, in order that the reader may refer to it as occasion requires.

L = length of the work perpendicular to the cross-sections.
B = width of roadbed.
h = centre height G F.
H = centre height A F, from the intersection of the side slopes, on the mid cross-section.
H′ = centre height A F on the first end cross-section.
H″ = centre height A F on the second end cross-section.

H, H′, H″ are called augmented centre heights.

G = twice $G\,A$, or the double augment of the centre height; $G\,A$ is called the augment of the centre height.

β = whole width or total base M N on the mid cross-section.

β' = total base M N on the first end cross-section.

β'' = total base M N and the second end cross-section.

σ = angle of side slope B D H or B A M.

σ' = angle of side slope C E Q or C A N.

$\frac{1}{2}\,d$ = G G′, the distance of a point on the roadbed from the centre.

S_h = sum of the end centre heights G F.

D_h = difference of the same.

S_H = sum of the augmented end centre heights A F, or augmented sum of centre heights $= H' + H''$.

D_H = difference of the same $= H' - H''$.

S_b = sum of total bases H Q or M N at the ends $= \beta' + \beta''$.

D_b = difference of the same $= \beta' - \beta''$.

S'_b = sum of the half end widths G D or G E of roadbed = B when the width is uniform.

D'_b = difference of the same = 0 when the width is uniform.

S'_h = sum of all the four side heights B H, C Q; B H + C Q may be called the total side height of a cross-section.

D'_h = difference of total side heights at the ends.

S''_h = sum of the end side heights B H.

D''_h = difference of the same.

S'''_h = sum of the end side heights C Q.

D'''_h = difference of the same.

S''_H = sum of the augmented end side heights B M.

D''_H = difference of the same.

S'''_H = sum of augmented end side heights C N.

D'''_H = difference of the same.

S''_d = sum of end distances out G H or A M.

D''_d = difference of the same.

S'''_d = sum of end distances out G Q or A N.

D'''_d = difference of the same.

S^{iv}_d = sum of the marginal distances out D H at the ends.

D^{iv}_d = difference of the same.

S^{v}_d = sum of marginal distances out E Q at the ends.

D^{v}_d = difference of the same.

S_m = sum of the end side slopes A B.

D_m = difference of the same.

S_n = sum of the end side slopes A C.

D_n = difference of the same.
A = area of mid cross-section.
A' = area of first end cross-section.
A'' = area of second end cross-section.
V = volume.
V_p = volume of the redundant prism on A D E.
V_s = volume contained between the ground surface and intersection of side slopes.
V_w = volume of the work.

Dimensions of the several Cross-sections.—The mid cross-section is an hypothetical one, having each of its linear dimensions and the auxilliary lines of its diagram, respectively, the mean between the like parts on the diagrams of the ends. The lines of the end cross-sections will be found by adding to or subtracting from the mean dimensions of the mid cross-section, respectively, the half difference of the like end dimensions. Before deriving these expressions we will remark that the differences of the end dimensions may, in the formulas, all be regarded as positive in relation to either one of the end cross-sections, but that in the application of the formulæ, we must give each difference its proper sign, in order to know the sign of the *product* of the differences. This is equivalent to considering the differences to be of like sign and their product positive if, on the end cross-section chosen, the greater height is coupled with the greater base; otherwise the product is negative.

For the mid Cross-section:—

$GF = \frac{1}{2} S_h$ $\quad CQ + BH = \frac{1}{2} S'_h$ $\quad AB = \frac{1}{2} S_m$
$HQ = \frac{1}{2} S_b$ $\quad GE = \frac{1}{2} S'_b$ $\quad AC = \frac{1}{2} S_n$

For the first end Cross-section:—

$GF = \frac{1}{2}(S_h + D_h)$, $CQ + BH = \frac{1}{2}(S'_h + D'_h)$, $AB = \frac{1}{2}(S_m + D_m)$
$HQ = \frac{1}{2}(S_b + D_b)$, $GE = \frac{1}{2}(S'_b + D'_b)$, $AN = \frac{1}{2}(S_n + D_n)$

For the second end Cross-section:—

$GF = \frac{1}{2}(S_h - D_h)$, $CQ + BH = \frac{1}{2}(S'_h - D'_h)$, $AB = \frac{1}{2}(S_m - D_m)$
$HQ = \frac{1}{2}(S_b - D_b)$, $GE = \frac{1}{2}(S'_b - D'_b)$ $\quad AN = \frac{1}{2}(S_n - D_n)$

We may also here note the following values:—

$$S_m = S''_H \operatorname{cosec} \sigma = S''_H \frac{1}{\sin. \sigma'} = S''_d \sec. \sigma = S''_d \frac{1}{\cos. \sigma'}.$$

$$D_m = D''_H \operatorname{cosec} \sigma = D''_H \frac{1}{\sin. \sigma} = D''_d \sec. \sigma = D''_d \frac{1}{\cos. \sigma}.$$

$$S_n = S'''_H \operatorname{cosec} \sigma' = S'''_H \frac{1}{\sin. \sigma} = S'''_d \sec. \sigma' = S'''_d \frac{1}{\cos. \sigma}.$$

$$D_n = D'''_H \operatorname{cosec} \sigma' = D'''_H \frac{1}{\sin. \sigma'}, = D'''_d \sec. \sigma' = D'''_d \frac{1}{\cos. \sigma'}.$$

$$S_m = (S''_h + G) \operatorname{cosec} \sigma = (S''_h + G) \frac{1}{\sin. \sigma}.$$

$$D_m = D''_h \operatorname{cosec} \sigma = D''_h \frac{1}{\sin. \sigma}.$$

$$S_n = (S'''_h + G) \operatorname{cosec} \sigma' = (S'''_h + G) \frac{1}{\sin. \sigma'}.$$

$$D_n = D'''_h \operatorname{cosec} \sigma' = D'''_h \frac{1}{\sin. \sigma'}.$$

These values of S_m, S_n, D_m, D_n, do not change their form if we suppose the angles of side slope to be unequal, and hence the vertical line A F to cut the roadbed out of the centre, as at G′. But in the case of unequal angles of side slope, put $G\,G' = \frac{1}{2} d$, and consider it positive when B A M is less than C A N, and negative in the opposite case. We shall then find the following values, which will also hold for equal angles of side slope by putting $d = 0$.

$$D\,G' = D\,G + G\,G' = \tfrac{1}{2}(B + d);\ G'\,E = G\,E - G\,G' = \tfrac{1}{2}(B - d).$$

$$S_m = (S^{iv}_d + B + d) \sec \sigma = (S^{iv}_d + B + d) \frac{1}{\cos. \sigma}.$$

$$D_m = D^{iv}_d \sec. \sigma = D^{iv}_d \frac{1}{\cos. \sigma}.$$

$$S_n = (S^{v}_d + B - d) \sec. \sigma' = (S^{v}_d + B - d) \frac{1}{\cos. \sigma'}.$$

$$D_n = D^{v}_d \sec. \sigma' = D^{v}_d \frac{1}{\cos. \sigma'}.$$

(To be continued.)

AN EXAMINATION OF SOME EXPERIMENTAL FACTS BEARING UPON THE PROPER RATIO OF THE LENGTH AND BREADTH OF STEAMSHIPS.

By Alban C. Stimers, Naval Engineer

(Concluded from page 309.)

In the following table the foregoing mean ratios of length to breadth are employed in the same manner as before to obtain the per centum of displacement required for the longitudinal iron of the hulls.

a.	b.	c.	d.	e.	f.	g.	h.	k.	m.
Class.	Ratio of L to B.	L.	B.	D	Surface.	Comparative Surface	Comparative L to B.	Comparative weights of Long. Iron	Per cent. of Displacem't of Long. Iron
Example.	6·33	6·333	1·000	0·600	14·0277	1·00000	1·00000	1·00000	18·40
A	3·38	4·167	1·233	0·740	11·5687	0·82470	0·53368	0·44012	8·10
B	4·15	4·777	1·151	0·691	12·3021	0·87699	0·65526	0·57465	10·57
C	4·71	5·199	1·104	0·662	12·7771	0·91085	0·74368	0·67738	12·46
D	5·71	5·911	1·035	0·621	13·5761	0·96786	0·90158	0·87260	16·06
E	6·98	6·757	0·968	0·581	14·4727	1·03172	1·10210	1·13761	20·92

Adding 3 per centum for *transverse stiffening* and 15 per centum for *equipments* in the same manner as before, and we have for the total weights of vessel, exclusive of machinery, coals and cargo, the following:—

Class	A	26·10	per centum	of the	displacement.
"	B	28·57	"	"	"	"
"	C	30·46	"	"	"	"
"	D	34·06	"	"	"	"
"	E	38·92	"	"	"	"

These weights of vessel are taken in connection with the coefficients of performance of each class as before to determine the actual displacements, powers and weights of steam machinery and weights of coals necessary in each case to carry 3,000 tons of cargo a distance of 3,000 miles in ten days. The results are given in the following table:—

Class	Coefficient of Performance.	Weight of Cargo.	Weight of Hull and Equipments.	Weight of Steam Machinery,	Weight of Coals.	Mean Displacem't.	Horses Power.	Cost of Hull and Equipments.	Cost of Steam Machinery.	Total Cost.
		Tons.	Tons.	Tons.	Tons.	Tons.		$	$	$
A	159·2	3,000	1,416	379	1,262	5,426	3,788	354,000	151,520	505,520
B	181·1	3,000	1,554	334	1,112	5,442	3,336	388,500	133,440	521,940
C	197·9	3,000	1,674	307	1,024	5,493	3,072	418,500	122,880	541,380
D	198·1	3,000	1,990	320	1,078	5,844	3,199	497,500	127,960	625,460
E	252·4	3,000	2,347	256	854	6,030	2,564	586,750	102,560	689,310

Let the annual expense of capital be 32 per cent., and the coal account represent eight round trips per annum with coal at $6 per ton in the bunkers as before; and we have the comparative annual expense in the following table:—

Class.	A.	B.	C.	D.	E.
	$	$	$	$	$
Annual expense of capital....	161,766	167,021	173,242	200,147	220,579
Annual expense of coals...........	121,152	106,752	98,304	103,488	81,984
Total of the variable expenses...	282,918	273,773	271,546	303,635	302,563

Again assuming the gross earnings of each ship per annum at $360,000 above the unenumerated expenses and the *net* earnings will be as follows:—

Class A	$77,082
" B	86,227
" C	88,454
" D	56,365
" E	57,437

And the per centa which these sums bear to the first cost of the ships, or, in other words, to the amount of capital invested, are as follows:—

Class A	15·25
" B	16·52
" C	16·34
" D	9·01
" E	8·33

Again, the ratio of four lengths to one breadth proves a better proportion for earning large dividends upon the capital invested than any higher ratio; but again, the difference between this and the ratio of 5 to 1 is essentially nothing, being only 0·15 of one per cent. The excess over the ratio of 3·38 to 1 is only 0·77 of one per cent., while over that of 5·71, or say 6 to 1, it is 7·51 per cent., and over that of 7 to 1 it is 8·19 per cent.

It might be claimed that we would get more satisfactory results if we were to select from each class, the vessel which shows the best coefficient of performance. I have, therefore, done this, and give the particulars in the following table:—

Class	Names of Vessels.	Ratios of Length to Breadth.	Speed in Knots per hour.	$\frac{V^3 \times D^{\frac{2}{3}}}{H.P.}$
A	Lion............	3·37 to 1	9·529	196·2
B	London.........	3·96 to 1	9·508	208·6
C	Resistance.....	5·18 to 1	10·372	245·7
D	Miranda....	5·77 to 1	10·750	247·5
E	Himalaya......	7·38 to 1	12·900	297·4

In the following table the above ratios of length to breadth are employed in the same manner as heretofore to obtain the proportion which the weight of the longitudinal iron bears to the displacement.

a.	b.	c.	d.	e.	f.	g.	h.	k.	m.
CLASS.	Ratios of L to B.	L.	B.	D.	Surface.	Comparative Surface.	Comparative L. to D.	Comparative weights of Long. Iron.	Per ct. of Displacement of Long. Iron.
Example	6·33	6·333	1.000	0·600	14·0277	1·00000	1·00000	1·00000	18·40
A	3·37	4·159	1·234	0·740	11·5550	0·82373	0·53240	0·43860	8·05
B	3·96	4·631	1·169	0·702	12·1178	0·86385	0·62385	0·53891	9·92
C	5 18	5·539	1·069	0·642	13·1612	0·91687	0·81789	0·74990	13·80
D	5·77	5·952	1·032	0·619	13·6171	0·97074	0·91105	0·88439	16·27
E	7·38	7·013	0·950	0·570	14·7329	1·05027	1·16526	1·22384	22·52

Adding to the quantities in column m, the 3 per cent. for *transverse stiffening* and 15 per cent for *equipments* in the same manner as heretofore and we have the following:—

Class A .... 26·05 per centum of the displacement.
" B .... 27·92 " " " "
" C .... 31·80 " " " "
" D .... 34·27 " " " "
" E .... 40·52 " " " "

These weights and the coefficients of performance of each class in this case are employed as heretofore in the following table:

CLASS.	Co efficient of Performance.	Weight of Cargo.	Weight of Hull and Equipments.	W'ht of Steam Machinery.	W'ht of Coals.	Mean Displacement.	Horses Power.	Cost of Hull and Equipments.	Cost of Steam Machinery.	Total Cost.
		Tons.	Tons.	Tons.	Tons.	Tons.		$	$	$
A	196·2	3,000	1,335	296	986	5,124	2,958	333,750	118,320	452,070
B	208·6	3,000	1,452	281	936	2,201	2,810	363,000	112,400	475,400
C	245·7	3,000	1,701	244	810	5,350	2,432	425,250	97,280	522,530
D	247·5	3,000	1,909	248	826	5,570	2,480	477,250	99,200	576,450
E	297·4	3,000	2,440	217	724	6,019	2,173	610,000	86,920	696,920

Assuming the annual expenses for capital and for coals at the same rates as heretofore, and we have the results in the following table:—

CLASS.	A.	B.	C.	D.	E.
	$	$	$	$	$
Annual expense of capital.........	144,662	152,128	167,201	184,474	223,020
Annual expense of coals...........	94,656	89,856	77,760	79,296	69,504
Total of the variable expenses...	239,318	241,984	234,961	263,770	292,524

With the gross earnings the same as has been heretofore assumed the *net* earnings will be as follows:

Class A $120,682
" B 118,016
" C 125,039
" D 96,230
" E 67,476

And the per centa which these bear to the first cost of the ships are as follows:—

Class A .... 26·70
" B .... 24·82
" C .... 23·93
" D .... 16·69
" E .... 9·68

Here the ratio of $3\frac{3}{8}$ lengths to 1 breadth is the superior proportion for earning money on a transatlantic voyage. It will pay 1·88 per cent. better dividends than the ratio of 4 to 1; 2·77 per cent. better than 5 to 1; 10 per cent. better than 6 to 1, and 17 per cent. better than $7\frac{3}{8}$ to 1.

When a capitalist invests money in a steamship enterprise he does so for the purpose of making such capital productive. There is no advantage to him in achieving a high coefficient of engineering performance unless there is connected with it a correspondingly high rate of dividends. In this country it is also an advanaage in favor of any peculiarities of the steamship if they reduce the amount of capital required to inaugurate the desired undertaking.

In the following table is stated the advaltages and disadvantages in these respects of the various proportions of length to breadth just examined as developed by the trials at the measured mile of English naval screw steamers.

Class.	Ratio of L. to B.	Comparative amount of capital required, according to			Annual Dividends earned when longest vessels pay expenses only, according to		
		Means of all the Vessels.	Means of better half of vessels.	Best vessel in each class	Means of all the vessels.	Means of better half of vessels.	Best vessel in each class.
A.	$3\frac{3}{8}$ to 1	75	73	65	4 per cent.	7 per cent.	17 per cent.
B.	4 to 1	75	76	68	8 " "	8 " "	15 " "
C.	5 to 1	80	79	75	7 " "	8 " "	14 " "
D.	6 to 1	90	91	83	2 " "	1 " "	7 " "
E.	7 to 1	100	100	100	0 " "	0 " "	0 " "

In choosing the proportion which should be given to a proposed transatlantic steamer, the above table would indicate that of 4 to 1 as being the most profitable, the rate of dividends being a little higher than that of 5 to 1, but the difference is very slight, and in every case the absolute net earnings are the greatest with the proportion of 5 to 1; whence the dividends would be greatest with that proportion under circumstances which reduced the earnings to the expenses of the shorter ships.

The lesson which this investigation of these trials teaches is, therefore, I think, clearly in favor of giving transatlantic steamers the proportion of 5 lengths to 1 breadth.

Mechanics, Physics, and Chemistry.

NOTES ON CRYSTALLOGRAPHY.

By W. H. Wahl.

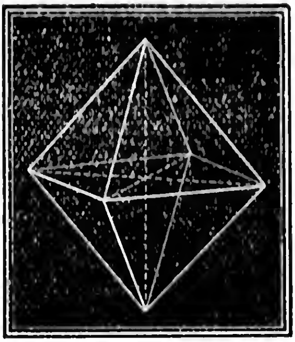
A crystallographic system is well defined as the assemblage of all the simple forms built upon the same law of symmetry, and of all the possible combinations of these forms with each other.

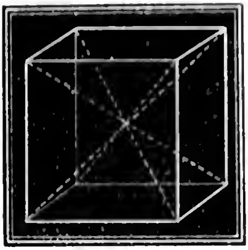
In previous papers it was noticed that if a comparison was instituted between the axial crosses of different crystals, they would be found to differ essentially from each other. If these differences are carefully studied, one cannot fail to be impressed with the fact that they are deep seated, and that they are the infallible indicators of characteristic pecularities in the internal structure of crystals; peculiarities which affect in a remarkable degree their so-called physical properties. The behavior of the individual towards light, heat and electricity; the relative hardness, lustre and tenacity of its parts seem to be absolutely dependent upon the character of the axial framework about which it is built up.

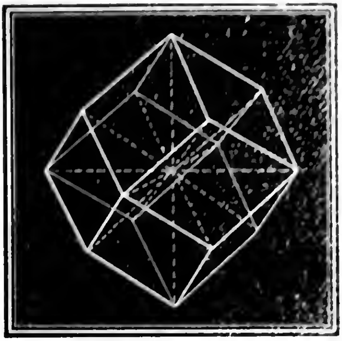
It is clear, therefore, that if a rational classification of crystals can be instituted, based upon their axial resemblances and dissimilarities, the clue has been found which will guide the student from the labyrinth of confusion into which the contemplation of an almost infinite variety of form has placed him. It will be no barren labor, but one well calculated to impress the mind of the novice with surprise and pleasure, to delve into this labyrinth and to find how readily complexity resolves itself into simplicity—to find in forms totally unlike and to all appearances totally unrelated, the same law of symmetry, simple and unmistakable, uniting them.

Crystallographers do not construct for each crystal all the *possible* axes in explaining its properties and relations. Such a procedure would render hopeless indeed any attempt at classification, as a momentary inspection of the accompanying figures will show. The figures here represented are known as the Octohedron, Hexahedron (cube), and Dodecahedron respectively. As will hereafter be shown, these forms bear to each other a close relationship; but we should seek this relationship in vain if, for instance, the angles

Fig. 1. Fig. 2. Fig. 3.







were taken as the points of departure, and the axes were assumed as joining them. With the Octohedron, then, we should find three, with the Hexahedron four, and with the Dodecahedron seven axes, and these axial systems differ from each other not only as regards number, but also in their mutual inclination and length, and the conclusion we should be warranted in asserting from such premises would be, that the forms in question were wholly unrelated; a conclusion quite at variance with that announced above. Without entering further into the details of similar comparisons, which might be multiplied at pleasure, it may be stated that the most exhaustive study of many forms has led to the belief that a cross of

Fig. 4.

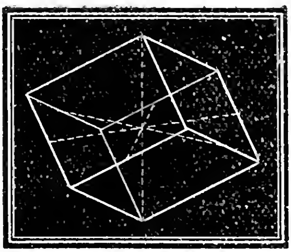
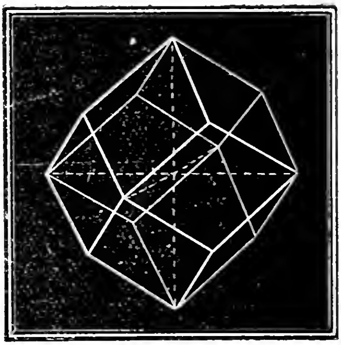


Fig. 5.



three, or at most of four lines uniting certain terminal parts constitutes the true framework about which the parts have been located with more or less symmetry. By far the greater number of crystals

are analyzed by three such imaginary lines, while but a comparatively small number require four; none, however, have as yet been found in nature or prepared in the laboratory which required more than four axes for its complete elucidation.

Fig. 6.

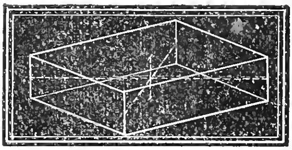
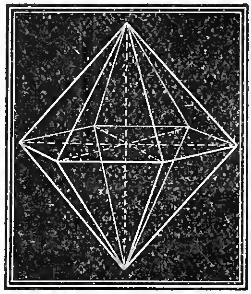


Fig. 7.



A glance at the preceding figures will show some forms with three and with four axes.

Here, then, we have obviously before us one of those axial differences so pregnant with importance in originating those physical peculiarities previously alluded to. Whether or not this alone is sufficient to account for all the physical characteristics presented by

Fig. 9.

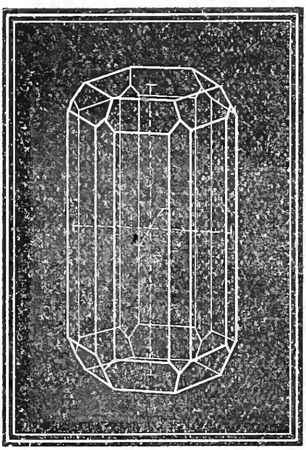


Fig. 8.

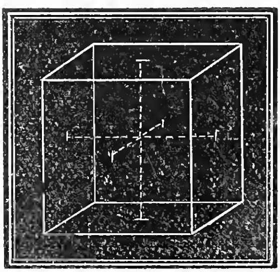
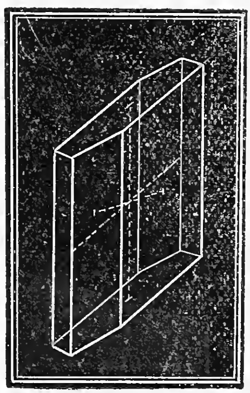


Fig. 10.



various crystals, is a query which can only be answered upon further analysis. An inspection of several crystallized minerals may answer it. Orthoclase, Dichroite and Rock-salt are three minerals

crystallizing in forms which, so far as the *number* of their respective axial systems is concerned, are identical: each individual has three axes, but as regards their physical properties, these minerals stand strongly contrasted. The crystal of the last named may be cleaved with equal perfection in three directions, corresponding to the direction of the axes, the lustre of each of the faces is the same, and the light or heat rays in their passage through the crystal in any direction are similarly affected. The individual of the second mineral, by its peculiar action upon the light which it transmits reveals a complete difference in its internal structure from the one just considered. The light which reaches the eye after passing through it in the direction of one of the axes, is blue, while that which passes in the direction of either of the others is yellowish.

With Orthoclase, we have a cleavage nearly perfect in the direction of one of the axes, less perfect in another, while in the third, it is nearly, if not altogether wanting. The lustre of its surfaces also is not the same, certain ones having the appearance of mother of pearl, others the strong, even lustre of glass—properties strikingly different from the behavior of rock salt.

Here, then, we have examples—they might be duplicated by the score—which clearly indicate that the characteristics of crystals are but imperfectly accounted for, in the classification thus far established; which, as will be remembered, is a classification based simply upon the number of the axes.

If the crystals just instanced are subjected to a closer scrutiny, we shall not fail to bring to light certain differences in these apparently identical axial systems upon which important functions depend, and to which the unconformable behavior of our examples may unhesitatingly be referred. Instituting the comparison between the crystals of Rocksalt and Dichroite—a difference in the relative lengths of the axes in each will be observed—with the first, all the axes are equal in length; with the second all the axes are unequal. In every other respect the framework of these substances is identical; with both, the axes are three in number and intersect at right angles. Upon this difference, therefore, in the relative lengths of their axes, the peculiar behavior of the minerals, Rocksalt and Dichroite, in relation to the perfection with which they cleave in different directions, and their action upon the character of the light or heat they transmit, must depend. Between the individual of Rocksalt and Orthoclase the same dissimilarity exists as we have found

between the first and Dichroite, affording, if it were desired, a substantiation of the proposition just asserted. By comparing together the crystal of Dichroite and Orthoclase, an axial dissimilarity of a new character presents itself. It is, namely, that though in the number and in relative irregularity of the individual axes, the framework of the two is the same, yet in the first named the axes all intersect at right angles; while with the last, certain of the axes intersect at oblique angles. This dissimilarity, while it does not seem to determine any of the great classes of physical differences in crystals, is yet the originator of a degree of dissymmetry unknown with crystals devoid of axial obliquity. It is of inestimable service in furnishing us with an additional basis upon which to carry our classification of crystals to an extent so exhaustive, that the various groups thus established are not unwieldy or complex, but simple and readily managed.

The analysis, to recapitulate, then, to which we have subjected various crystals in relation to their axes, has resulted in the detection of differences of three kinds, by which they can be rationally divided into groups and systems. To evolve these groups and their mutual relations is the last step to be taken. Proceeding from properties which affect the greatest number or the whole body of crystallized substances, we may be able to divide them all into several great groups; each of these may subsequently yield to subdivision by the presence or absence of certain properties less general than that which determined the first division, and this process of differentiation is continued until it ceases to be advantageous.

The most general division which can be made of crystals is one which depends upon the *number* of the axes. As has already been mentioned, these are in every case either three or four. It is possible, therefore, upon this principle, to establish two general groups, into one or the other of which, all crystallized substances will fall, viz., the triaxial and quadraxial groups. By far the greater number of crystals will be found to fall under the first of these groups, and by taking advantage of the knowledge derived from the examples previously given, this group (the triaxial) may be farther differentiated. The three axes of the group either intersect each other at right angles, or they do so at angles more or less oblique: the triaxial group may therefore be divided into two sub-groups—Orthometric from (Ορθος straight, and Μετρον, measure), in which all the axes form rectangular intersections; and Clinometric (from

κλινω, I incline, and μετρον, measure), in which one or more of the axes form oblique intersections.

By keeping still in mind the lesson learned from the example of the three minerals, a subdivision of the orthometric and clinometric sub-groups is readily managed. The only unapplied feature remaining is the relative inequality or differences in the lengths of the axes. This we will proceed to apply; and we are thus enabled to establish the following systems:

From the orthometric sub-group there may be obtained:

The Monometric (or Regular) system, in which the three axes crossing at right angles are all equal in length.

The Dimetric (or Quadratic) system, in which two of the three axes are equal in length, while the third is either greater or less.

The Trimetric (or Orthorhombic) system, which differs from the others in the essential particular that all the axes are unequal.

From the clinometric sub-group there may be obtained three systems, though only the two given below occur in nature.

The Monoclinic system, in which two of the three axes intersect obliquely, while the third cuts both of them at right angles.

The Triclinic system, in which each of the three axes forms an oblique intersection with the others.

The quadraxial group is not susceptible of further analysis, as but one system has as yet been recognized under it, namely: the hexagonal system: in which three of the four axes lie in one plane, intersect each other at an angle of 60°, and are equal in length: while a fourth axis of varying length is placed vertically upon them.

The study of the individual forms occurring under each of these systems, as well as the general character of the respective systems, will form the material for subsequent papers. The results of this exhaustive analysis, with the statement of which this note may close, are conveniently represented by the accompanying tabular arrangement.

GROUP.	SUB-GROUP.	SYSTEM.
TRIAXIAL,	*Orthometric*,	Monometric. Dimetric. Trimetric.
	Clinometric,	Monoclinic. Triclinic.
QUADRAXIAL,		Hexagonal.

PENNSYLVANIA'S FOUNDATION STONES.

Lecture delivered before the Franklin Institute, Thursday, Dec. 22d, 1870.
By Prof. Leeds.

(Continued from page 345.)

The Position of Pennsylvania in the Geological Scale.

The crust had hardened on the fiery deep. The earth had been one vast crucible. From myriad points ran out diverging lines of crystalline force, as when the first blasts of winter strike down upon the surface of the ponds. The school-boy hastening to the noisy class-room shouts with ecstasy, because he knows that these long needles of ice before nightfall will have linked themselves into a fast net-work, in whose loops a million tinier crystals shall be caught, and the whole shall have hardened into a faultless mirror. From point to point covering the globe with as many lines as those which show the mariner on his faithful chart his place upon the trackless deep, from zone to zone shot forth the rock crystals. A house that is to be built upon shifting sands must needs have firm foundation, a bridge that spans a torrent must root its abutments deep in either bank, and plant its piers like feet where the shock of the trunks and hulks of boats and huge stones carried down when springtime swells its stream into a freshet, can never budge them.

Upon the fiery lake that has no bottom, upon the lava that stretches down to the earth's centre, upon the flints and sand more liquid than what the fire-pot of the glass-house shows, upon molten metal, compared with which, the red hot rivulets that flow into the hissing troughs when the iron furnace is tapped, are cold and sluggish, a foundation is to be laid that shall endure until the last great day of doom. Over a fiery liquid which rose and fell with every change of moon, and rolled great tidal waves around the earth with the yearly and diurnal revolution of the sun—that piled itself up into a great mountain over 26 miles in height about the equator flung upwards from the poles as the earth spun round at the rate of 3 miles per second—that had its surface currents streaming onward to Polar Seas, and its submarine currents flowing downward towards the middle, as now the gulf and arctic streams change and purify the five great oceans—over this whirling tide a floor is to be laid upon which the behemoth and the mastodon may walk without

the slightest tremor to terrify, and where the tiniest mote that enjoys the breath of life shall gambol in the sunshine, unconscious of the abyss that yawns beneath—over phosphoric fumes, that would fill the air with horror, over sulphurous vapors that would bleach and suffocate, over gases that would make of earth a sepulchre, a house is to be built that shall be man's glorious habitation.

Therefore were unyielding blocks of hornblende used for the foundation. And not only hornblende, but porphyry and basalt, and chiefly that most enduring building stone of all, solid granite. They were dovetailed and morticed one into the other by interlacing crystals, and where they showed signs of cracking, dykes of metal were pierced through, as builders key the walls of granaries and warehouses together with iron girders.

Thus was the foundation laid by which the vast superstructure was to be supported.

And when all had been done, and strength sufficient was given to last even to this present day, a great excess of material remained.

What was to be done with it?

It was to be made the soil and home of innumerable plants and animals.

When we wish that a plant should flourish, we dig about its root and break up the ground into clods, so that its tender rootlets may be strong enough to push their way through every chink and crevice, and find drink and nourishment awaiting them.

When an animal would live it tears its food to pieces, so that the juices may flow out and the acids of the stomach may seize upon each morsel of gelatine and fibre.

When the earth's first crust was to be made ready to receive plant-life and animal, it had to be ploughed up and harrowed, it had to be channelled and crevassed and scooped into hill and dale, and to be made soft, yielding, porous.

Things crystalline are strong but lifeless; things full of holes and cells are plastic, organic, living. Granites and porphyrys are good for foundation walls, but muds and sands make good ground for tillage.

Water, as I said in my first lecture, has been this great mediator between the inorganic and organic kingdom, the power which evoked life from the dead, and beauty and motion from the barren sea.

On a thousand millstreams water is busy in doing its work for man. It is grinding the crops into food. It is knitting fibre into

stuff. It is pounding the products of the furnace into bar and rail and bloom. Endless cranks and pulleys, levers, pistons, saws and hammers are spinning and whirling and falling at its bidding.

But how much of the power of the mill-stream is consumed after it has prepared man's tools, food and garments? With how much less energy does Niagara plunge headlong into the Emeral Pool because some child of mammon has perched an obscure papermill upon its brink?

With the first drop of rain that fell from the heaven above, with the first hill, however low, with the first lap of the ocean upon the shore, with the first heaving of the tide, water commenced to wear away the coping of the foundation and build up the superstructure. Fourteen miles of rock, piled one above the other, attest the thoroughness with which it has done its work.

I say fourteen miles instead of seven, as I stated at the outset, because I believe the considerations which have been brought forward are sufficient to overthrow the theory that the 37,000 feet that underlie the hitherto so-called fossil bearing rocks were the stratified sediments deposited upon the sea-bottom from the ashes of submarine volcanoes, viz., that the granites and other crystalline rocks found in these 37,000 feet graduate imperceptibly into gneiss and non-crystalline rocks; that the granites are interstratified with mud slates and other layers arising from the debris of crystalline rocks, and finally that fragments of crystalline rocks are found mingled in with sedimentary beds of later origin.

If any doubt remained it would be crushed by this little stone that I am now holding in my hand. It came from the Laurentian rocks of Canada. It was given by its discoverer, Dr. Sterry Hunt, the chemist of the Canadian survey, to my friend Mr. Trautwine, the eminent civil engineer of this city. It shows a polished surface of green serpentine, traversed with beautiful wavy lines of white marble. The latter are the crystallized tubes and branching canals of a coralline animal; the serpentine has taken the place of the flesh and body of the animal itself. The specimen shows that these Laurentian rocks were not devoid of life, but may have teemed with it. And since *this* specimen has been found, many others have been dug up throughout Canada and along the Gulf of St. Lawrence. The animal has been called the Eozoon Canadense—Eozooe, from two Greek words, one, Eos, signifying *dawn*, the other, zoon, meaning animal—the animal that was harbinger of the dawning of life upon

our globe. It has not only been found in Canada, but also in the limestones of Chelmsford, in north eastern Massachusetts, showing that there, too, rocks but lately regarded as Azoic are of the Laurentian age, and contain fossils. The evidence has been rapidly accumulating during the course of the past five years, and already five more species have been found in rocks of a similar character. In great probability, now that the attention of naturalists has been called to the true nature of these beds, and instead of passing over them with indifference, geologists are everywhere examining them with the most careful scrutiny; before another five years have passed away, we may be made acquainted with not only five but with 50 different kinds of animals that flourished in the falsely called Azoic age.

If these 25,000 feet of Laurentian sediments contain life, it is opposed to all probability that the Huronian are devoid of any relics of it, and that an immense gap, during which 12,000 feet of muds and schists were deposited and centuries rolled away, intervened, during which no life existed upon our globe, and that a new creation took place at the opening of the Silurian age.

I said, in the beginning of the lecture, that it might be doubted whether anywhere there existed at the present day upon the face of the globe a fragment of the original crust that remained exposed to view: and that if it was to be found, it probably was along the line of the Laurentian Hills.

In the light of recent discoveries, may not even that doubt be regarded as dispelled? When the foundation had been laid, was it not meet and proper that that foundation should be concealed beneath the surface and only the superstructure appear?—when the granites and basalts, which are as little adapted to supply habitations for animals, or food for plants, or ores yielding to the art of man, as our modern traps and lavas, had served their use, that they should give way to something more soft and penetrable?

As dough is mixed through and through with leaven, so is the superstructure—(this more than dozen miles of sediment)—with the germs of life, with food and fuel, with oil, salt, metal, and even meat and flesh. Leavened, so that animals and plants, as they developed into forms of rarer beauty, and bloomed with brighter intelligences, should have that which nourish them onward to a higher life, until man should bud forth into the full and perfect flower of nature's creative energies.

Said Dean Swift, and this alone might atone for everything of savage and bitter that he said of frail and fickle manhood—"he that makes two blades of grass bloom where but one grew before, is a public benefactor." But in Swift's day, the chemist, the mineralogist and the geologist were unborn. What is to be said of him who, like the illustrious Prof. Hofmann, has found the secret of a hundred new dyes, and clothed the peasant with a robe more brilliant than that worn by a Tyrian king! What of the poor Philadelphia printer who robbed the tempest and the thunder cloud of its terrors! What of the poor bookseller's apprentice, who did more than any one else to make of electricity and magnetism vehicles that should outrun time and keep pace with thought! What of Count Rumford, the Yankee lad whom a Bavarian prince ennobled, and who first showed what was the proper amount and kind of food for rations for artisans and soldiers! What of Liebig, the father of organic chemistry, who taught us how to make food imperishable.

He that discovers a new continent does much, but he that finds that which will feed a continent of people does vastly more.

And in this superstructure, these piles of sediment, ready for use, are stored away fuel, light and food which we yet know little of.

Of its magazines of coal and its recently discovered wells of oil, we people of Pennsylvania know full well—and the riches, the comforts, the blessings that attend them we know. The government of Prussia is opening up yearly new mines of salt, and around those mines in the course of the last few years great factories have sprung that extract of the salt refuse its magnesia, and send their refuse to recuperate the exhausted lands of our own Southern States with the potash which they contain.

Salts of iodine and bromine are being mined, so that these bodies, invaluable to medicine and photography, are sinking in price so rapidly as to be constantly employed for fresh uses.

As our vast cities grow, they must be fed, and new substances must be dug from the ground to supply the wants which a denser and more cultured population bring.

Therefore must every geologist examine more critically the country about us, and the chemist must put its soils and minerals and ores to a more searching test to find something of new value.

Therefore must an enlightened public do, of its free will, what the monarchies of Europe do by compulsory taxation, and found

laboratories and institute surveys, which may discover and provide beforehand for the needs of a growing population.

The chemist and geologist have their high and appointed stations as much as priest or politician. A Franklin, who turned away from the splendor of courts to perfect electrical machines, and a Faraday, who put away from him during the course of a lifetime a quarter of a million of pounds sterling, and preferred the public good to riches, are not the least noble of those who say "the common wealth is their greatest wealth, the public weal their highest good."

Perhaps there are some here who will have an instrumentality in solving some of the problems which I have brought before you to-night—some who may make the glorious discovery that these foundation stones of Eastern Pennsylvania, those which we have so often tramped over before, looking only for the minerals they contain, are not Azoic, but have once been peopled with life. To bring into order what has hitherto baffled the knowledge of geologists, to show precisely of what age these rocks are, and, if possible, to detect the broken and confused relics of crab and shell which they may contain, I solicit the help and study of every young student in my audience. And to encourage and stimulate us by your interest and sympathy, to found for us laboratories wherein we may successfully examine the material that we have gathered from the fields or dug from beneath the hills, I turn to you, my older friends and much valued fellow-members of the Institute.

ON A NEW CONNECTION FOR THE INDUCTION COIL.

By Prof. Edwin J. Houston.

THE following experiments were made at the Central High School of Philadelphia, with the view of increasing the quantity of the spark of the induction coil without greatly diminishing its length. The instrument used was made by Ritchie, of Boston, and will throw the spark six inches in free air.

One of the poles or ends of the secondary wire was connected with the earth by a copper wire attached to a gas pipe. The other pole was connected with a wire, which rested on a large lecture table holding the coil. On turning the break piece, the electricity, instead of being lost by passing along the wires to the earth, jumped

from the pole connected with the table, to that connected with the earth. The thickness of the spark was greatly increased, its length diminished, and its color changed to a silvery white, as when a Leyden jar is placed in the path of the discharge.

While the electricity is flowing between the points, long sparks may be drawn from any part of the table, or from any metallic article within eight or nine feet of the coil. On one occasion the gas was lighted by a spark drawn from the finger of a person standing on the floor. The gas pipe being in almost perfect connection with the earth, the spark must have been given to it from the body of the person.

On another occasion one wire was attached to the gas pipe as before, and the other to a stove, whose pipe connects with that of another stove in an adjoining room. The thickness of the spark was greatly increased. Sparks were drawn from the distant stove, and even from a small steam engine, which latter was fully thirty feet from the coil. In all the experiments it was found necessary to insulate the handle of the break piece, as a slight shock was experienced at every break. The poles being kept at a distance from each other less than the insulating power of the coil, six inches, no danger of injuring the instrument was apprehended. In one instance sparks were drawn, in a room underneath the adjoining room, from a wire which connected with the table on which the coil rested.

These facts showing great loss of the electricity, but indicating the need for a large conductor, probably to allow the rapid discharge of the secondary wire, a large insulated conductor was extemporized by placing some old tin stills and percolators on large glass jars. On connecting one of the poles with this conductor, and the other with the gas pipe, the quantity of the spark was increased, though there was reason to believe that, with a larger conductor, better results would have been obtained. The conductor was then divided into two, of about equal size, which were connected with the poles. The quantity of the spark was increased, with, however, great diminution in the length. By successively diminishing the size of one of the conductors, and increasing that of the other, the length of the spark was increased, without any sensible diminution in its quantity, until, when one of the conductors was less than one square foot in surface, a fine quantity spark of about *five inches* was obtained.

It will be noticed that this connection is somewhat similar to that used in the common cylinder or plate machine, in which one of the conductors, generally the negative, is connected with the earth, and the quantity of the electricity thereby increased.

In all the experiments in which one pole was in partial connection with the earth, as when it rested on the table, the loss of electricity must have been very great, for several gas and water pipes are in connection with the table. If, then, the table merely serves as an imperfectly insulated conductor, which allows the rapid induction of electricity in the secondary wire by its rapid discharge, and thereby, notwithstanding the loss, gives so great an increase in the quantity of the spark, it would seem that if, instead of the table, an insulated conductor of very large surface were used, a much greater increase in quantity would be obtained.

It would seem from the above experiments that the maximum increase will be obtained when one of the poles is connected with an insulated conductor, say several hundred square feet in surface, and the other with the earth.

ON THE USE OF HYDRAULIC MORTAR.

[Translated from "Die hydraulischen Mortel" of Dr. W. Michaelis, for the Journal of the Franklin Institute.]

By Adolph Ott.

(Continued from page 337.)

On the Preparation of the Mixture.

In preparing hydraulic mortar, it is advisable to begin in mixing the dry lime or cement-powder with clean sand. When these form a thorough mixture, the requisite quantity of water must be gradually added under constant stirring up of the material. In no other way can a uniformly and evenly mixed mortar be obtained with rapidly binding lime or cement; while, if the lime or cement is first mixed with water, a partial binding and consequent clogging of the material takes place, which either precludes the possibility of a perfect and satisfactory mixture of the sand then added, or renders it at least extremely difficult.

It is self-understood that the water must be clean, that is to say, free from all such substances as may interfere with the adhesion of the particles, like clay, mud, grease and mucilaginous matter.

The mixture of water ought to be such as to secure a product of the most even consistency; this is no doubt obtained with less difficulty and more chance of success through the use of mortar-

machines. If, however, the mixure has to be made by hand-work, careful and reliable persons ought to be chosen for the work, which should be paid for by the day or week, and not given out under contract.

It is of especial importance not to make the mortar too soft, because, as we have already repeatedly shown, and as has been proven by numerous experiments, the quality and solidity of the mortar is directly dependent on the quantity of water it contains at the moment of its hardening.

While very good Portland cement, for instance, requires only 30 parts in weight of water for every 100 parts in weight of cement to produce a mortar of sufficient consistency, there are other descriptions which must be mixed with at least 40 parts of water; but as in either case the quantity of water chemically bound is almost precisely the same, and as the surplus water evaporates in course of time, it is evident that the density and solidity of the former cement must be far greater than that of the latter.

With very good Portland cement, however, the disadvantage of an excessive admixture of water is averted, in a great measure, in consequence of its specific weight and peculiar powder-like form, which cause its speedy settling towards the bottom, and its effectual separation from the surplus water; but another inconvenience frequently arises in the separation of the mortar-mass, inasmuch as the coarser particles settle near the bottom, while the finer ones remain nearer to the surface. Whenever other descriptions of hydraulic lime or quickly hardening cement are used, the quantity of water to be admixed must be most carefully measured, or its due proportion ascertained by previous repeated experiments.

An especially careful preparation is necessary for pozzuolana mortar, because with them all reactions are expected to take place after the mixture has been completed.

The mixture of hydrate of lime and pozzuolana must be as dense and thorough as possible.

The pozzuolana ought to be reduced to very fine powder, and the mixture with the lime must be as effective and intimate as possible.

The use of a machine like Hertel's combined clay cutting apparatus is most commendable for this purpose; because the greatest possible density and uniformity of the mixture is thus obtained.

The preference must, in all instances, be given to the employment of machine power, because it is impossible to obtain a satis-

factory mixture by hand work in any other way than through a plentiful use of water. The result of this excessive admixture of water, however, is a soft, pap-like substance, which can never be made into a dense and solid mortar. It shrinks speedily, gets cracky, and yet remains slack. In cases where pozzuolana mortar is to be exposed to the influence of the turbulent sea, and where its strength and solidity is therefore most severely tried, the greatest care in its preparation is advisable. Nothing which may tend to increase its durability ought to be overlooked. In looking over the numerous directions given for the preparation of such mortar, it is surprising to see the wide difference of the several methods recommended, and the proportionately small quantity of lime almost universally advocated.

The former circumstance finds its explanation in the different descriptions of pozzuolana, or in the local peculiarities and influences of the places where it is found, or where it is to be used; and it is even advisable to experiment with regard to the various proportions of material to be used, in order to ascertain how to attain the most favorable result in any special case.

The second point, however, is worthy of a more minute consideration. In defining the hardening process of pozzuolana mortar, we have already made the remark that a great portion of the pozzuolana remains ineffective, in consequence of the relatively small quantity of lime used in its preparation.

This limited use of lime we explain in the following manner:

Whenever there is a great surplus quantity of pozzuolana the lime finds a sufficient quantity of easily accessible and binding substances, as silicic acid, alumina, &c.; in a short while the quicklime is thus almost completely converted into hardening compounds, and the consistence of the mortar is likewise secured in a comparatively small lapse of time.

But if, on the contrary, pozzuolana mortar is mixed with a quantity of lime capable of securing the only possible hydraulification of the lime, a very large proportion of this base would, for a long time, remain in the substance as quicklime; during this period the power of resistance as well as the density of the mortar would be materially impaired, while under water, through the agency of such an easily soluble substance; and it would take a long time before such mortar could resist the influence of water.

It is better, therefore, to renounce such proportion of the hydrau-

lificating faculty as would only become effective after a long lapse of time in all cases where water-mortar is to be made with pozzuolana for immediate use.

It is, however, undoubtedly advisable to take a greater proportion of lime, and to allow more time, in order that the various substances of which the mixture may be composed can have full chance to act upon one another before the mortar is brought into use.

In so doing, the following advantages are secured:

(1) The chemical reactions will be more complete.

(2) In consequence of the more uniform course of these reactions, the substance becomes more dense, and the consistence of the mortar, subsequent to the hardening process, is more safely secured.

After the pozzuolana has been reduced to the finest powder, it is mixed with lime, which must be previously reduced to a stiff, pap-like condition; to these materials a sufficient quantity of water has to be added to produce a mass of a certain consistence. The use of Hertel's clay cutting apparatus or of a similar machine is advisable. After leaving the substance alone for a few days, the mixing process has to be repeated several times with the addition of the requisite quantity of water.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Meeting, February 15th, 1871.

THE meeting was called to order at the usual hour, the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the stated meeting held March 8th, inst., donations to the library were received from the Society of Arts, the Institute of Civil Engineers, and Lieut. Col. Edward Sabine, London, England; Hon. Secretary of State, Hon. William D. Kelley, Washington; American Philosophical Society, Dr. E. P. Wyckoff, and Messrs. Hillibrand and Wolf, Philadelphia.

The committee appointed to report on the estimation of H. P. of engines and boilers reported progress.

The Secretary then read his monthly report on Novelties in Science and the Mechanic Arts, after which the Institute adjourned.

W. H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, March 15th, 1871.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair. The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers and reported that at a meeting held at the Hall, the Board organized in accordance with the annual election of January 25, by electing Bloomfield H. Moore and Charles Bullock, Curators; and William Hamilton, Actuary for the ensuing year; and by appointing the following standing committees:

On Instruction.

William H. Wahl,
Robert E. Rogers,
Enoch Lewis,
Washington Jones,
Robert Briggs.

On Elections and Resignations.

Henry G. Morris,
Henry Cartwright,
Clarence S. Bement,
William Helm,
Theo. Bergner.

On Stocks and Finance.

William Sellers,
Frederick Fraley,
J. Vaughan Merrick,
Enoch Lewis,
William P. Tatham.

On Publication.

Bloomfield H. Moore,
Samuel Sartain,
Charles Bullock,
Pliny E. Chase,
Joseph M. Wilson.

On Exhibitions.

J. Vaughan Merrick,
William Sellers,
Charles S. Close,
Bloomfield H. Moore,
Edward H. Williams.

On Sections.

John H. Cooper,
R. Eglesf. Griffith,
H. W. Bartol,
W. B. Le Van,
Hector Orr.

Furthermore, that at the stated meeting of the Board, held February 8th, 1871, donations to the library were received from the Royal Astronomical Society, the Royal Geographical Society, and the Institute of Civil Engineers, London, Eng., and the Steam Users' Association, Manchester, Eng.; the K. K. Geologischen Reichsanstalt, Vienna, Austria; the Natural History Society, Montreal, Canada; Col. James B. Eads, Chief Engineer Illinois and St. Louis Bridge; E. S. Cheesborough, City Engineer, Chicago, Ill.; John W. Bast, Surveyor General of California; and from D. Sheppard Holman, Philadelphia.

The resignations of membership in the Board were received, of Messrs. John Birkbeck and Clarence S. Bement, and accepted, with the order to be reported at the next meeting of the Institute. The

committee appointed at the last meeting to consider the mode of estimating the H. P. of boilers and engines reported progress.

The Secretary's report on Novelties in Science and the Mechanic Arts was then read.

Under the head of new business, the President announced the appointment of the following gentlemen upon the committees of the Institute for the ensuing year, to wit:

Library.

Charles Bullock,
Samuel Sartain,
Wm. P. Tatham,
Henry G. Morris,
Jos. M. Wilson,
Wm. H. Wahl,
Bloomfield H. Moore,
John C. Browne,
Percival Roberts,
Pliny E. Chase.

Arts and Manufactures.

William Adamson,
John H. Cooper,
Jacob Naylor,
Hector Orr,
Wm. G. Rhoads,
William P. Tatham,
Rafael Estrada,
James Sellers Bancroft,
Alfred Mellor.

Models.

Wm. B. Bement,
Edward Williams,
Ewd. Brown,
Theodore Bergner,
John Goehring,
D. S. Holman,
William B. Le Van,
Edwin Smith,
Charles McIlvain,
Addison Hutton.

Meteorology.

Isaac Norris, Jr.,
Robert E. Rogers,
William H. Wahl,
John Wise,
Thos. S. Speakman,
James A. Kirkpatrick,
Pliny E. Chase,
David Brooks,
Alexander Purvis,
John G. Moore.

Minerals.

John C. Trautwine,
F. A. Genth,
Theo. D. Rand,
R. Egglesfield Griffith,
Albert R. Leeds,
Clarence S. Bement,
S. B. Howell,
John C. Browne,
William H. Wahl,
Albert C. Peale.

Meetings.

Henry Cartwright,
Enoch Lewis,
Robert E. Rogers,
Ed. Longstreth,
B. C. Tilghman,
Bloomfield H. Moore,
Charles S. Close,
William H. Wahl,
Henry G. Morris,
R. E. Griffith.

The election of two members of the Board was ordered to fill vacancies caused by the resignation of Messrs. Birkbeck and Bement. Mr. Wm. Wharton, Jr. and B. C. Tilghman were, upon balloting, declared duly elected.

The meeting then adjourned.

WM. H. WAHL, *Secretary.*